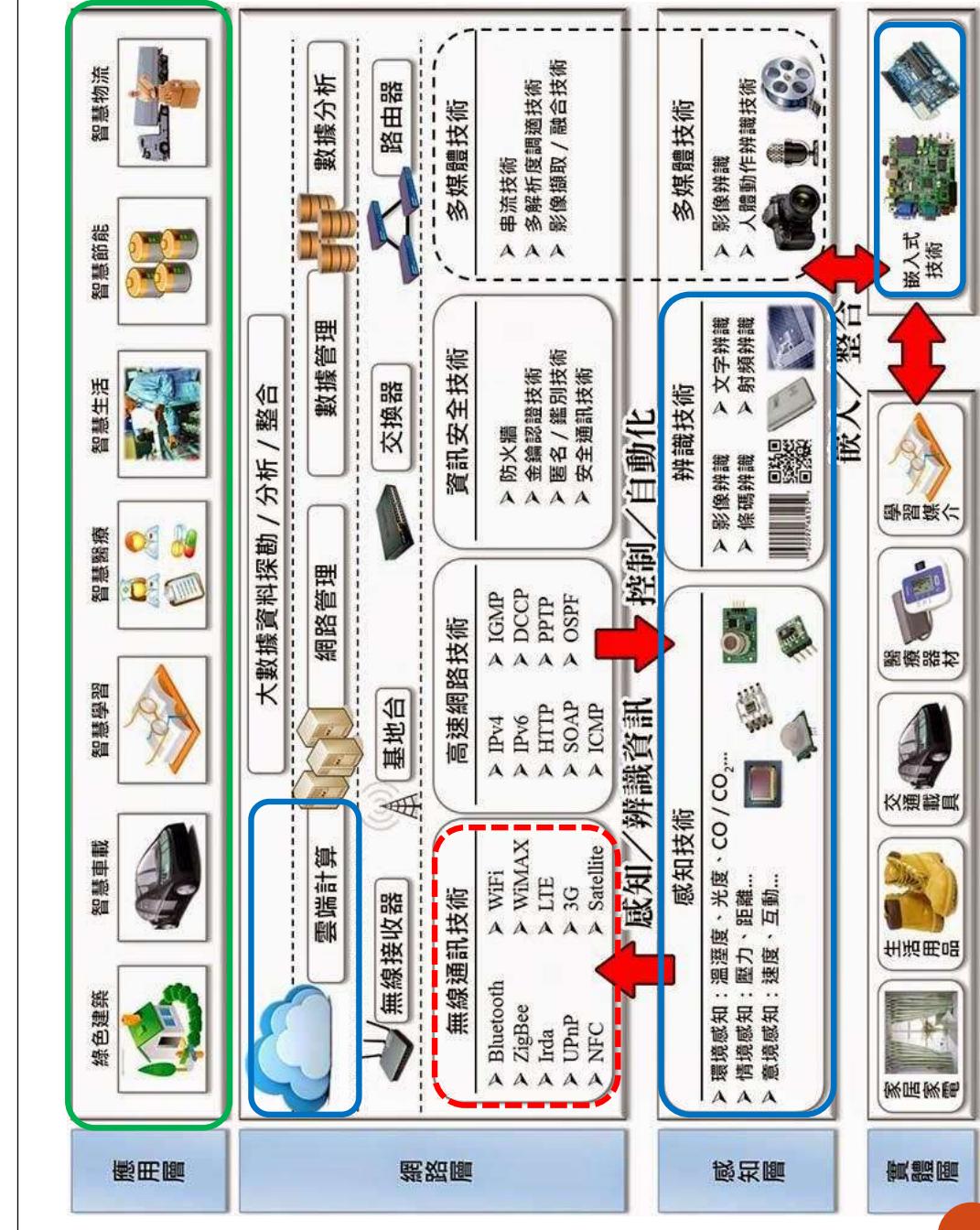


Lecture 5

LPWAN

Low Power Wide Area Network



IoT is transforming the world through unprecedented digitization

58

<https://www.cisco.com/c/en/us/solutions/internet-of-things/iot-control-center.html?socialshare=videoblade-5story>

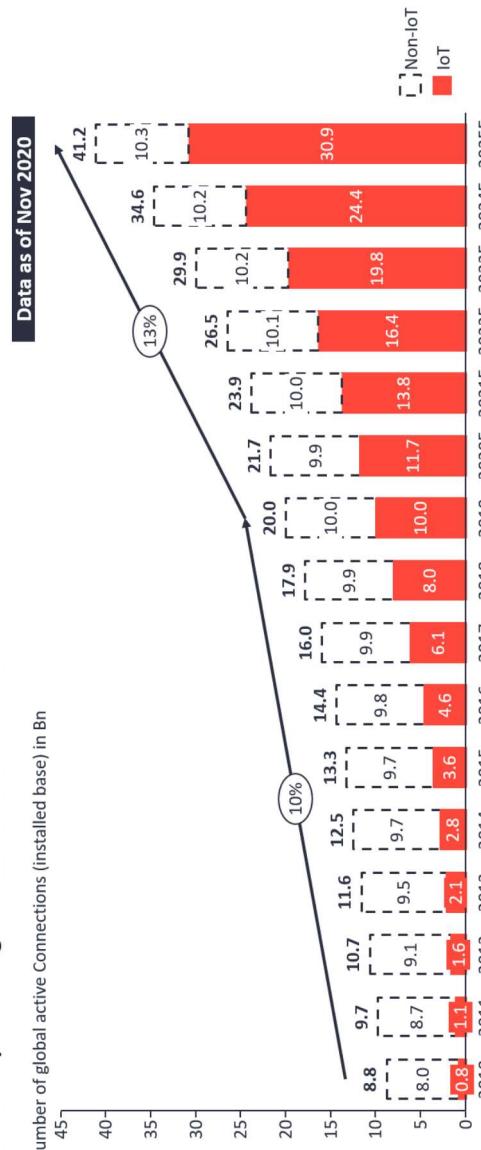


1d IoT markets

四〇〇

Total number of device connections (incl. Non-IoT)

20.0Bn in 2019- expected to grow 13% to 41.2Bn in 2025



Note: Non-**IoT** includes all mobile phones, tablets, PCs, laptops, and fixed line phones. IoT includes all consumer and B2B devices connected – see IoT break-down [here](#).

<https://iot-analytics.com/wp-content/uploads/2020/11/IoT-connections-total-number-of-device-connections-min.png>

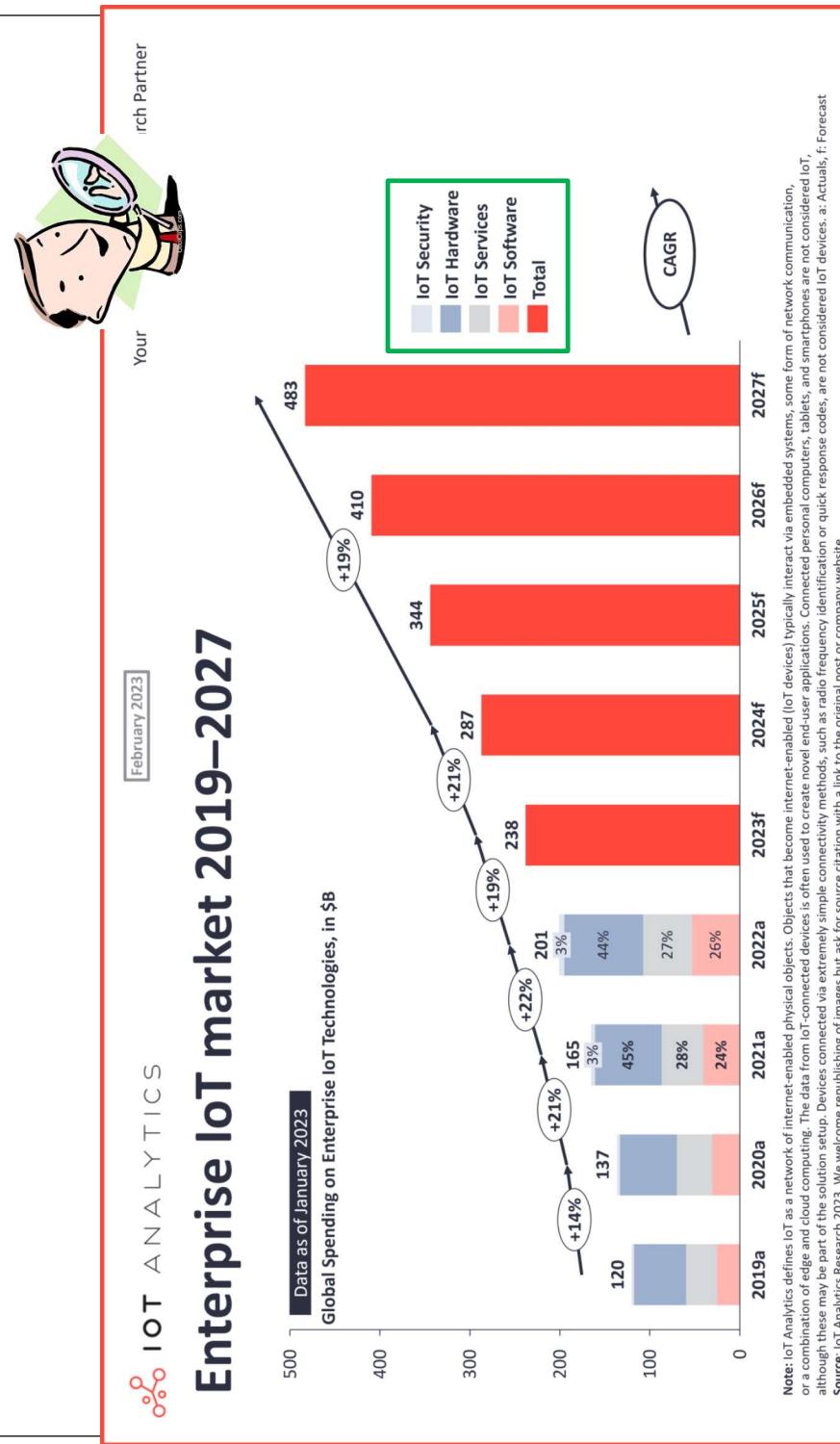
CAGR

$$\text{CAGR} = \left(\frac{\text{終值}}{\text{初值}} \right)^{\frac{1}{\text{年數}}} - 1$$

Compound Annual Growth Rate 複合年均成長率

Example: 初值=20、終值=41.2、年數=6；CAGR=?

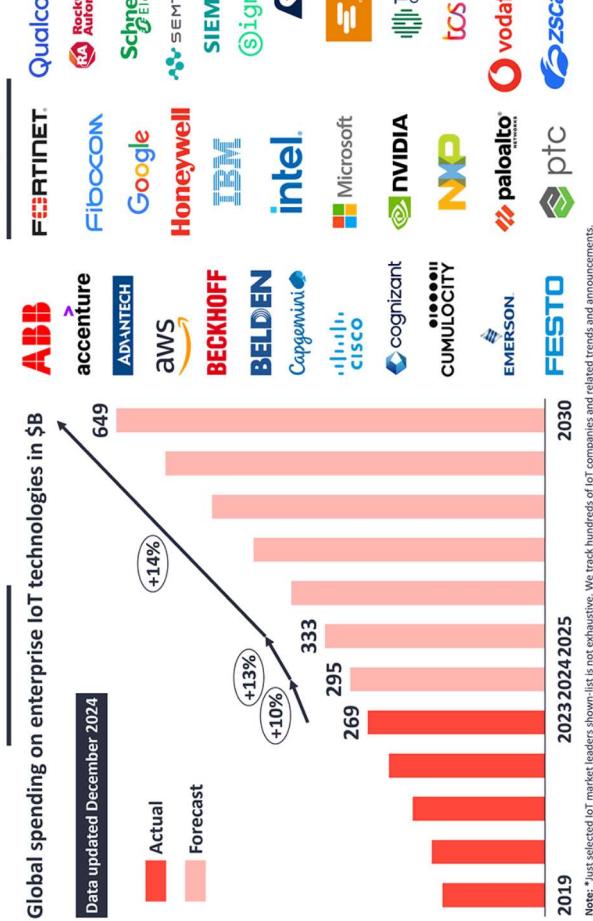
5



6

Market snapshot: Enterprise IoT

Market size & outlook



7

<https://iot-analytics.com/state-of-enterprise-iot/>

Market dynamics (selection*)

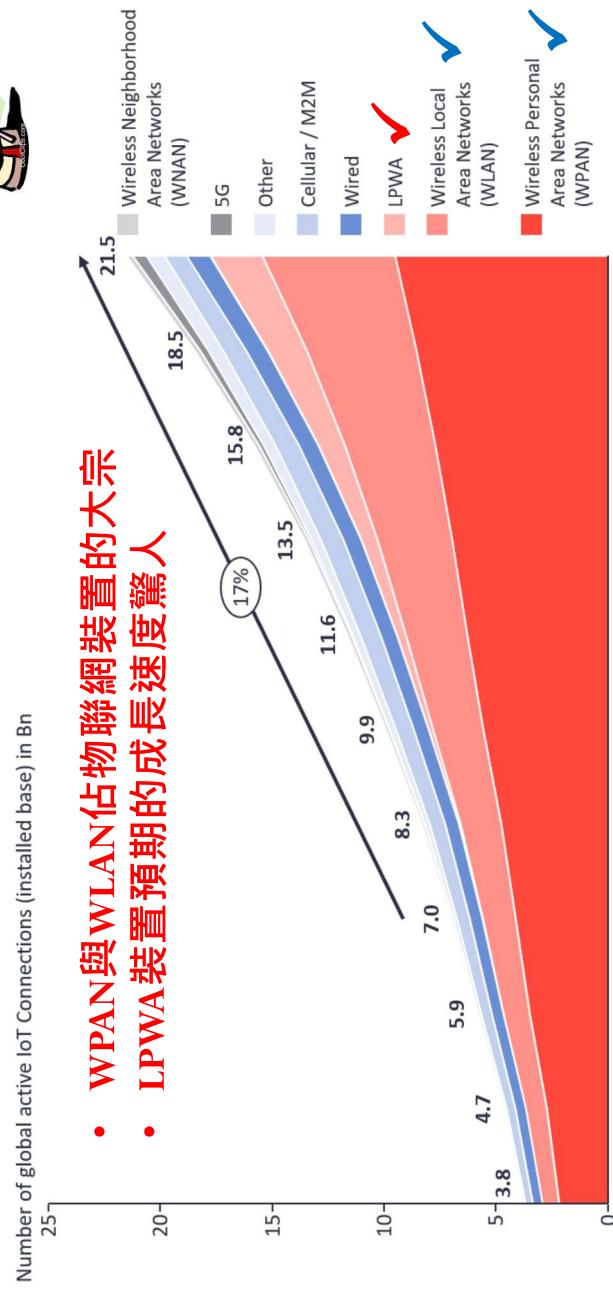


Note: * Just selected IoT market leaders shown—list is not exhaustive. We track hundreds of IoT companies and related trends and announcements. We welcome republishing or linking to the original post and company website.

Source: IoT Analytics Research 2025 State of IoT Spring 2025 & Global IoT Enterprise Spending Dashboard. We welcome republishing or linking to the original post and company website.

- IoT enterprise spending grew 10% in 2024, its lowest rate in over a decade
 - according to IoT Analytics' 89-page State of IoT Spring 2025 report (published February 2025).
- Hardware segments struggled the most, while **software** and **cloud-based** solutions continued to expand.
- India experienced 14% YoY IoT spending growth, while Europe experienced slower IoT adoption rates.
- New IoT products in late 2024 heavily focused on **AI, security, and connectivity**.

Global Number of Connected IoT Devices

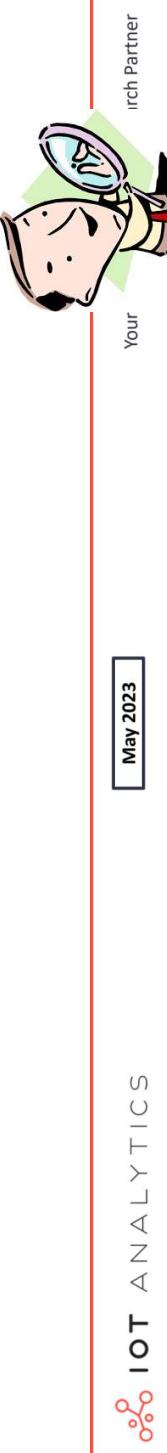


Note: IoT Connections do not include any computers, laptops, fixed phones, cellphones or tablets. Counted are active nodes/devices or gateways that concentrate the end-sensors, not every sensor/actuator. Simple one-directional communications technology not considered (e.g., RFID, NFC). Wired includes Ethernet and Fieldbuses (e.g., connected industrial PLCs or I/O modules); Cellular includes 2G, 3G, 4G; LPWA includes unlicensed and licensed low-power networks; WPAN includes Wi-Fi and related protocols; WLAN includes Wi-Fi and satellite and unclassified proprietary networks with any range.

Source: IoT Analytics Research 2018

9

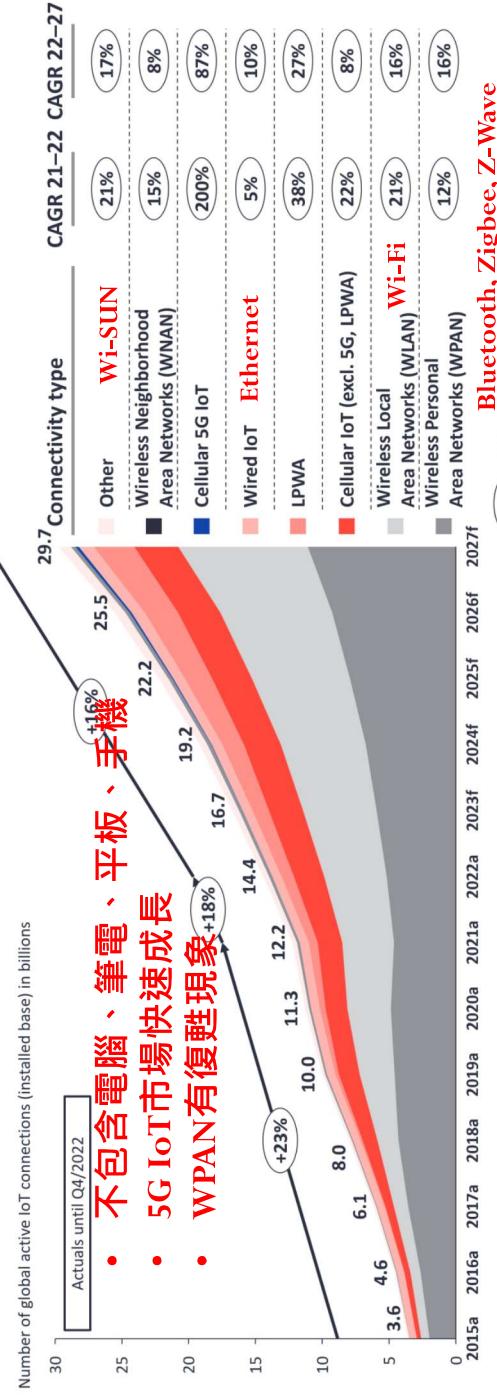
LPWAN : Low Power Wide Area Network 低功耗廣域網路



Actuals until Q4/2022

May 2023

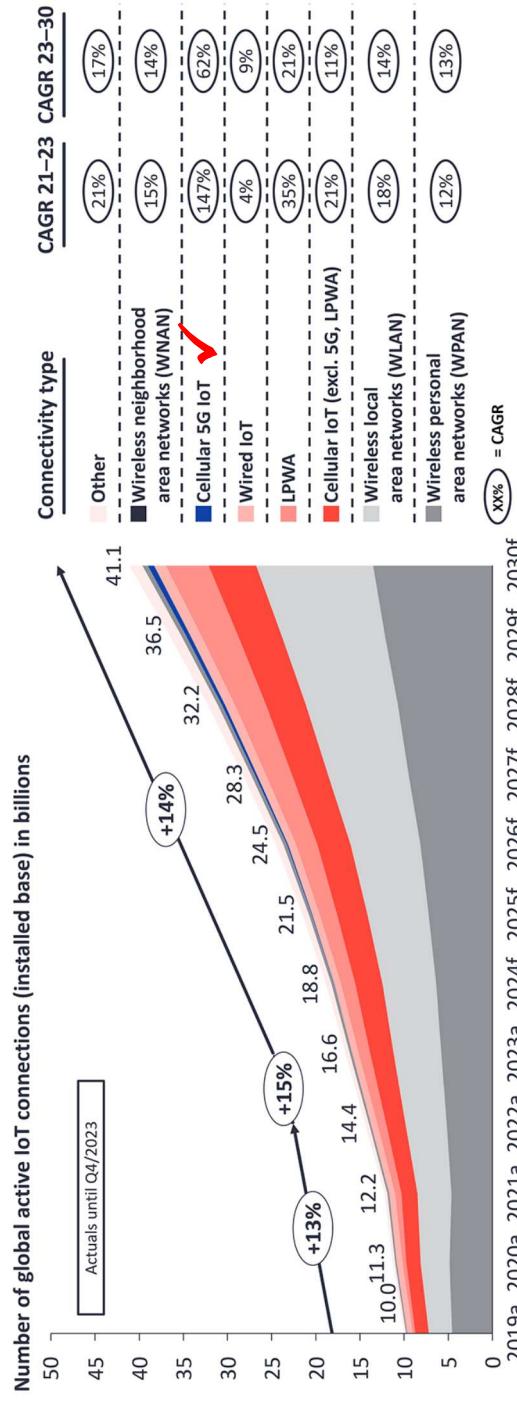
Global IoT market forecast (in billions of connected IoT devices)



Note: IoT connections do not include any computers, laptops, fixed phones, cellphones, or tablets. Counted are active nodes/devices or gateways that concentrate the end-sensors, not every sensor/actuator. Simple one-directional communications technology not considered (e.g., RFID, NFC). Wired includes Ethernet and Fieldbuses (e.g., connected industrial PLCs or I/O modules); Cellular includes 2G, 3G, 4G; LPWA includes unlicensed and licensed low-power networks; WLAN includes Wi-Fi and related protocols; WLAN includes Wi-Fi and satellite and unclassified proprietary networks with any range.

Source: IoT Analytics Research 2023. We welcome republishing of images but ask for source citation with a link to the original post and company website.

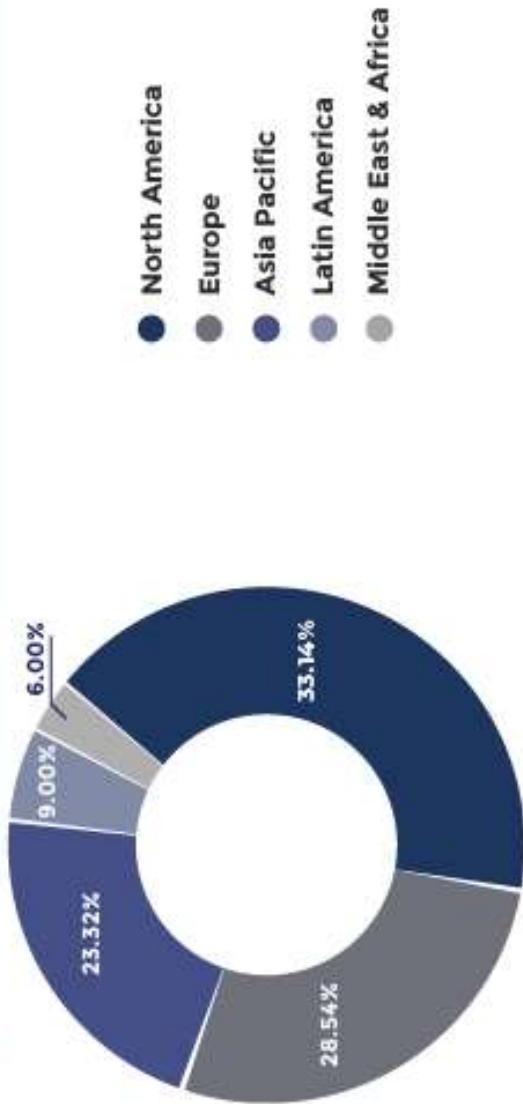
Global IoT market forecast (in billions of connected IoT devices)



INTERNET OF THINGS (IOT) MARKET SIZE 2023 TO 2033 (USD BILLION)



Internet of Things (IoT) Market Share, By Region, 2023 (%)



Fleetmatics: Vehicle Tracking



15

<https://www.youtube.com/watch?v=ib5WD-FlkOs&t=35s>

訂閱天下

最新出刊 ▶ 「美國員工一下班就找不到人」台商東進多坎坷？駐美台幹告白

亞馬遜Ring加碼台灣研發人才投資：專訪Ring產品長探索居家與社區安全創新之路

產業 > 科技
贊助



三

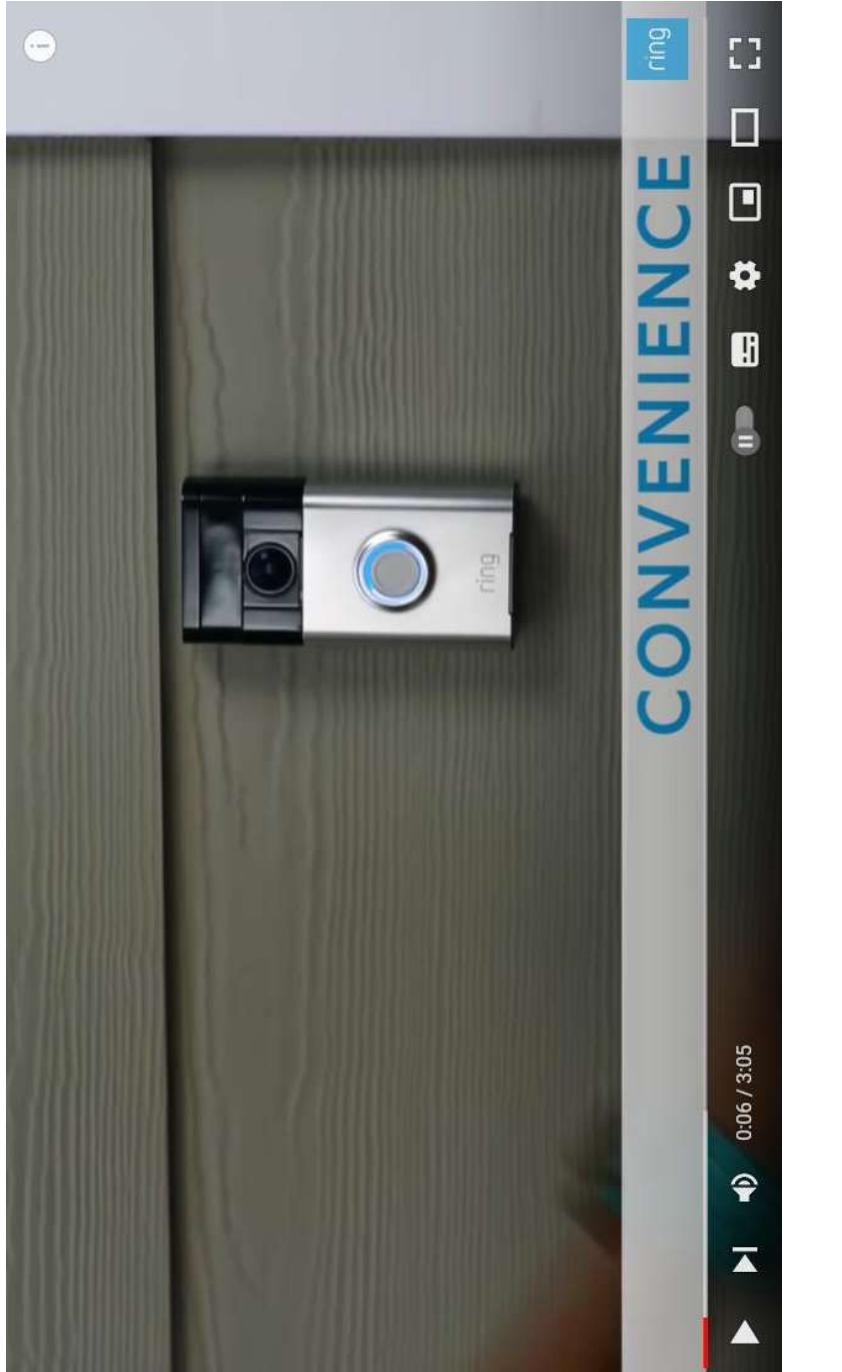
產業 > 科技

贊助

<https://www.cw.com.tw/article/5121629>

16

Amazon: Ring



17

<https://www.youtube.com/watch?v=v18sZI5AH4g&t=1s>

Top 10 IoT & telco trends—as seen at MWC 2024

Change of topic mentions in related press articles, MWC 2024 vs. MWC 2023 in %

Trend	Change (%)
AI	+104.8%
5G	+23.3%
Sustainability	+265.7%
Automotive	+46.7%
Smartphone	-50.2%
Security/Cybersecurity	-8.5%
WiFi 7	-28.0%
WiFi 6	-30.3%
Gen AI	+156.6%
Chipset	-43.0%
Virtual Reality	-59.4%
Wearable	-48.9%
Network Efficiency	-44.4%
IoT	-43.3%
6G	-10.7%

1 AI integration is enabling smarter, more efficient networks

2 Cellular network technologies are enhancing performance and services

3 GenAI is revolutionizing customer interactions and network management

4 Semiconductor and AI advancements redefine the future of vRAN

5 Integrating AI into connectivity and chipset technologies

6 5G RedCap chipsets, modules, and devices are advancing

7 Cellular and satellite ecosystem convergence enhances IoT connectivity

8 eSIM adoption for IoT and automotive on the rise

9 On-device AI to quantum-resistant technologies enhance cybersecurity

10 Telcos and manufacturers strive for sustainability

Source: IoT Analytics Research 2024 – MWC Barcelona 2024 Event Report—Analyst Takeaways. We welcome republishing of images but ask for source citation with a link to the original post and company website.

18

2024年MWC展概要

項目	內容
展出時間與地點	2月26日至29日在西班牙巴塞隆納展出
主題與焦點	<ul style="list-style-type: none">主題：「Future First」（未來優先）六大焦點：5G與B5G、萬物相連、人性化 人工智慧、工業4.0、創新科技及數位基因
國際參展廠商	Meta、諾基亞、愛立信、華為、高通、英特 爾、超微（AMD）及Telefonica、Orange、 Vodafone、STC、SK、KT等

台灣參展廠商

聯發科、宏達電、宏碁、仁寶、廣達、光寶
、啓碁、智邦、中磊、智易、合勤控、正文
、明泰、友訊、亞旭及電信三雄等

資料來源：MWC官網、各公司

黃晶琳 / 裏表

2024年MWC展概要

<https://money.udn.com/money/story/5612/7769134>

19

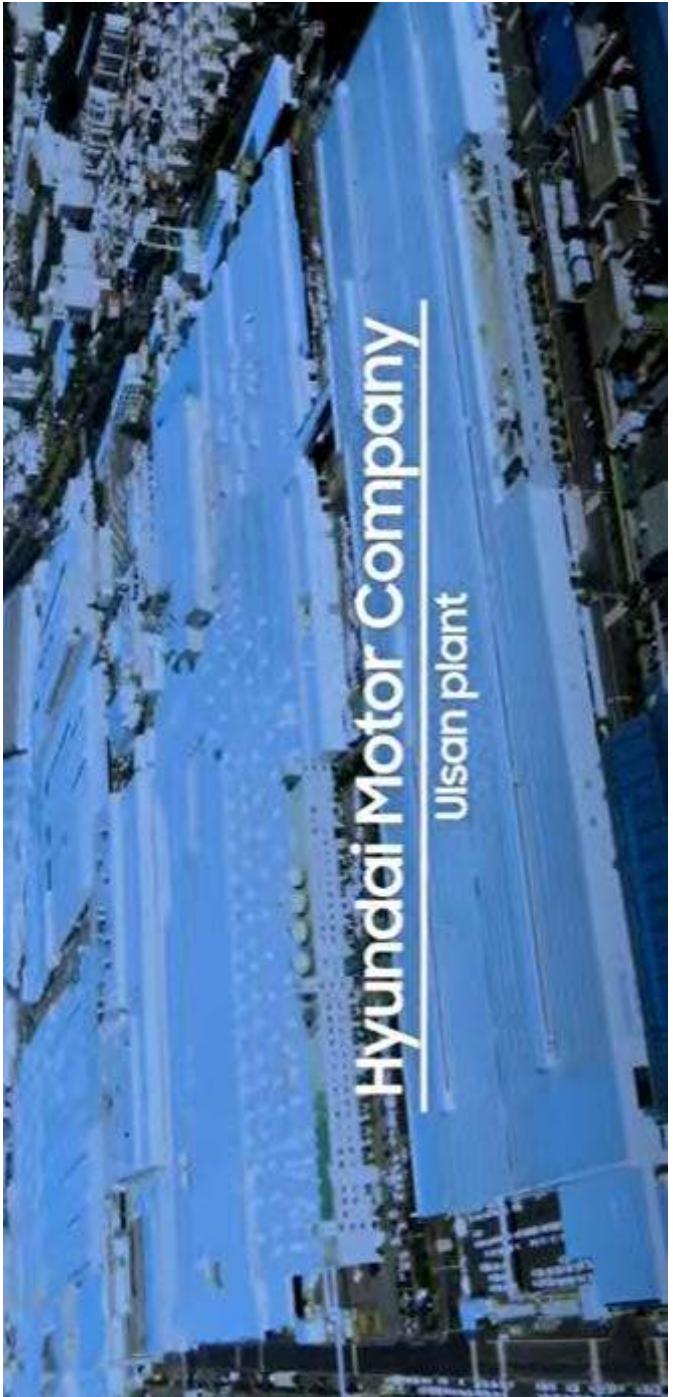
- 電信業：首波B2C & B2B Gen AI應用落地
- 智慧型手機：裝置端Gen AI崛起
 - On-device AI
 - AI語言模型：更大、更強，但也更小
 - LLM → SLM
 - Wi-Fi 7加速普及，Wi-Fi 8初露端倪
 - 5G RedCap加速IoT連接應用
 - 6G、衛星通訊與量子運算進展

2025年世界行動通訊大會(MWC 2025)已於3月初結束，全球科技產業的目光將再
次聚焦西班牙巴塞隆納...

<https://www.eettaiwan.com/20250311nt21-mwc-2025-trends/>

20

Demonstrating RedCap technology for Private 5G network | Hyundai x Samsung



<https://www.youtube.com/watch?v=uQtjCHc6m0w&t=1s>

21

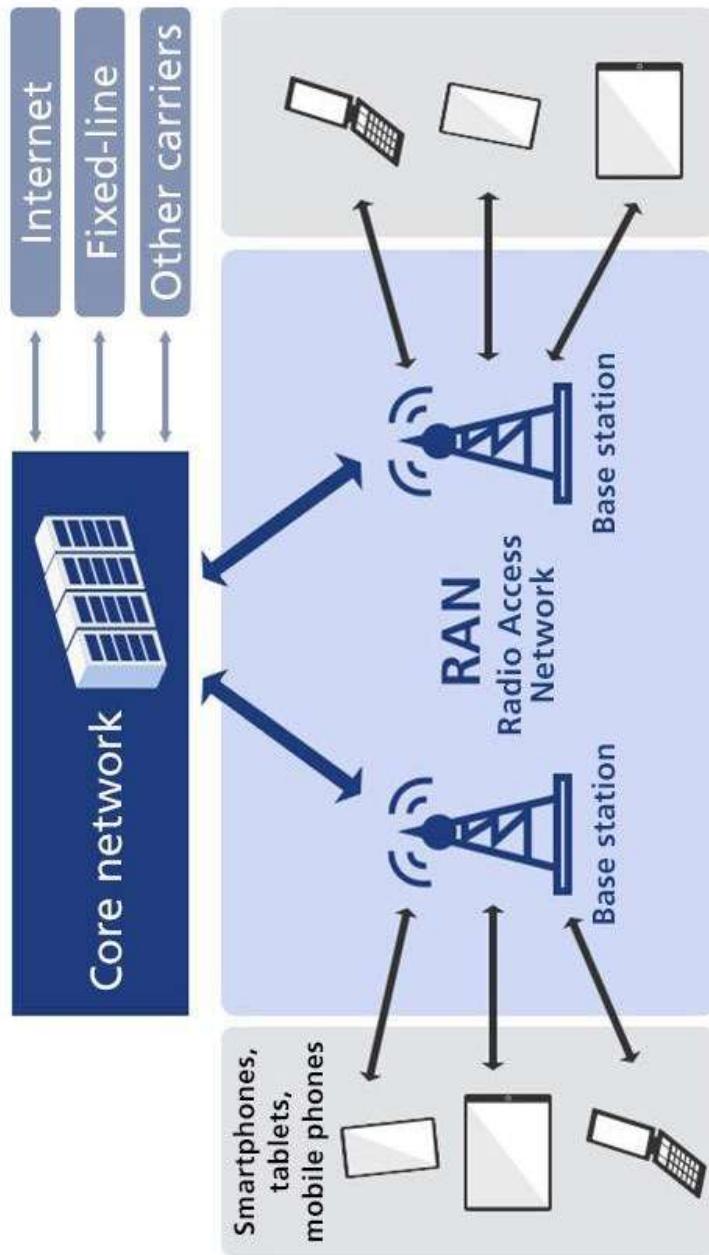
在智慧型手機上運行 生成式AI的趨勢將 在2024年實踐



Source：科技政策研究與資訊中心—
科技產業資訊室(iKnow)整理，2023年
8月 圖片來源：Qualcomm

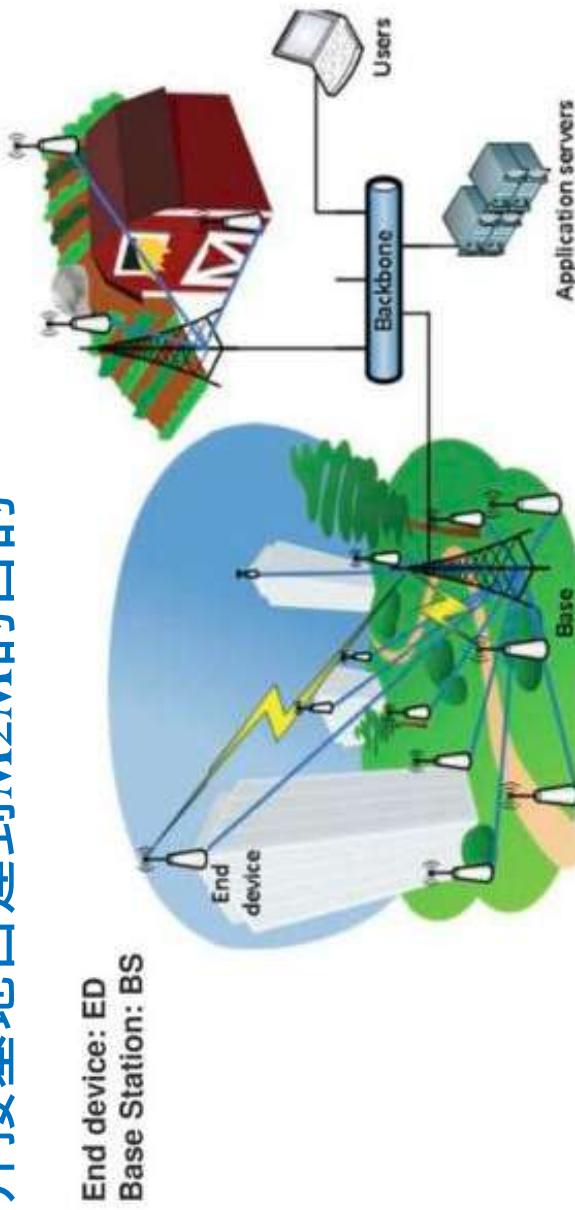
<https://iknow.stpi.niar.org.tw/Post/Read.aspx?PostID=19948>

22



Radio Access Network：移動通訊網路的重要組成之一，主要負責如手機、平板等行動裝置，與核心網路之間的無線通信。

以骨幹網路為核心，各用戶或終端裝置
交接基地台達到M2M的目的



典型的Cellular網路樣貌



Base station

25

物聯網無線通訊技術定位

速率

100Mbps

WiFi

4G, 5G
(高成本)

100kbps

Bluetooth
ZigBee

3G

100bps

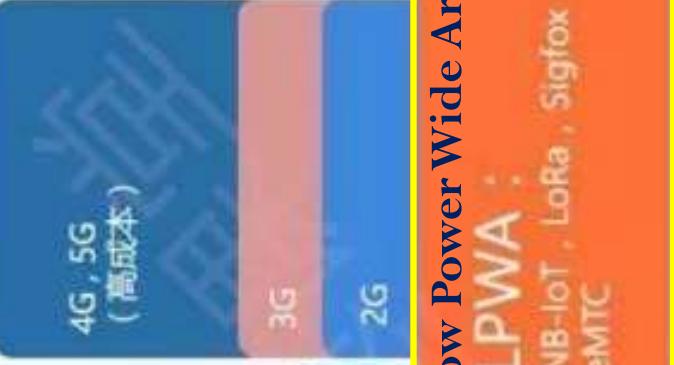
2G

Low Power Wide Area
LPWA
NB-IoT, LoRa, Sigfox
eMTC

1m

10km

100m



短距離

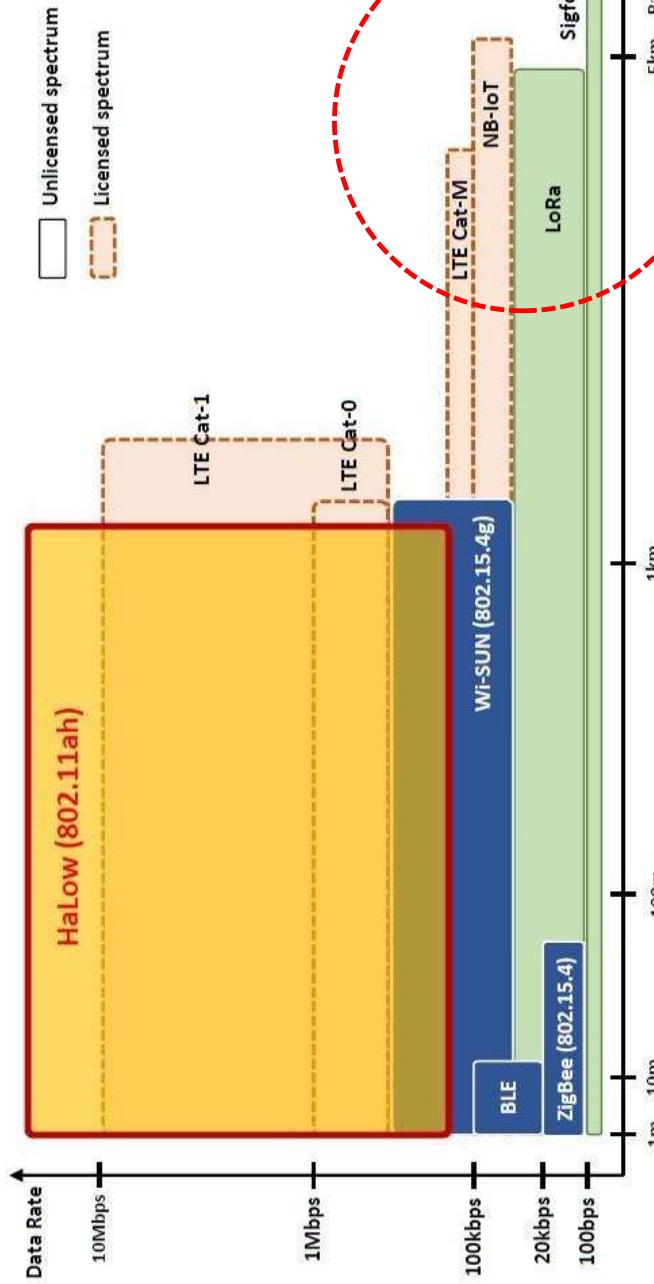
- WiFi
- Bluetooth
- Zigbee

長距離

- NB-IoT
- LoRa
- Sigfox
- ...

覆蓋

26



<https://www.eettaiwan.com/20190401nt11-wi-fi-802-11-ah/>

27

LPWAN Market 2018 – 2023: New Report Out Now

LPWAN Market Development

>1.1B 2023 CAGR 109%

IoT ANALYTICS

New Research - September 2018

Global LPWAN connections

7 Leading technologies

Solutions in 9 market segments

16 other relevant technologies

LPWAN

Insights that matter

RPM Analytics

sigfox **WEIGHTLESS**

NB-IoT **LTE-M**

EC-GSM-IoT

Comparison criteria:

- Technical features
- Ecosystem
- Use case suitability
- SWOT Analysis

Market Report: LPWAN 2018-2023 – Download Sample for more information

Fastest growing IoT connectivity technology (2017-2023)

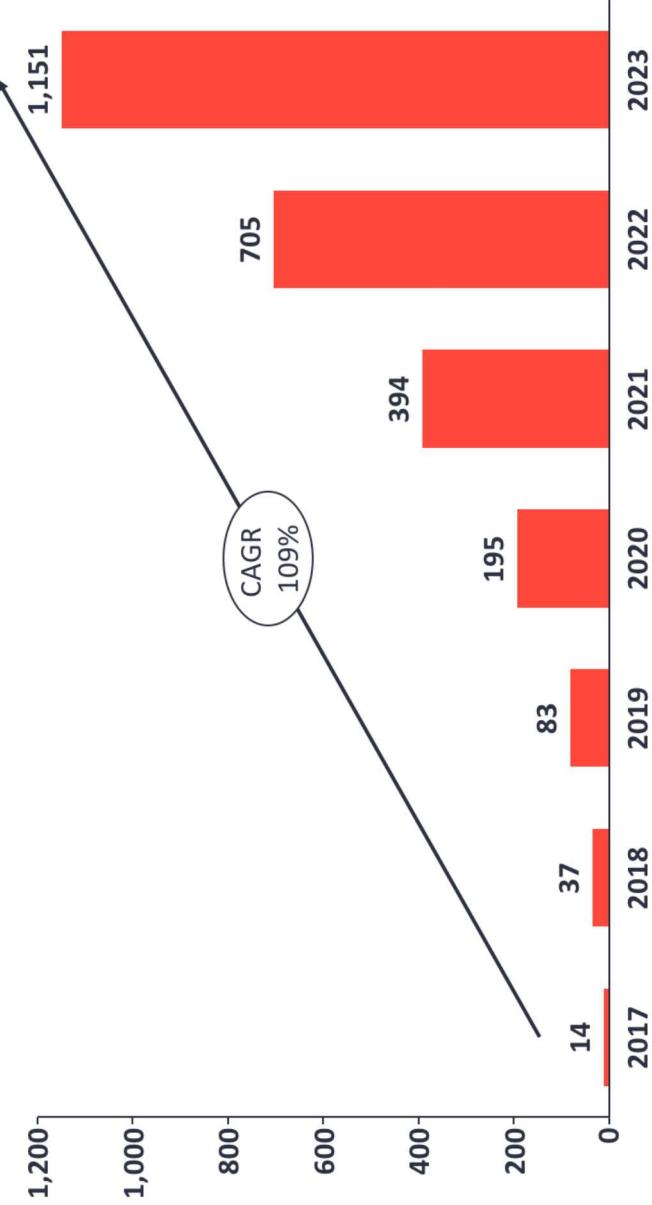
- Utilities the biggest segment
- Asia Pacific to become the leading adopter

37 LPWAN use cases analyzed in detail



Global LPWAN Market Size 2017-2023

Global LPWAN Market Size in # of connected devices (millions)



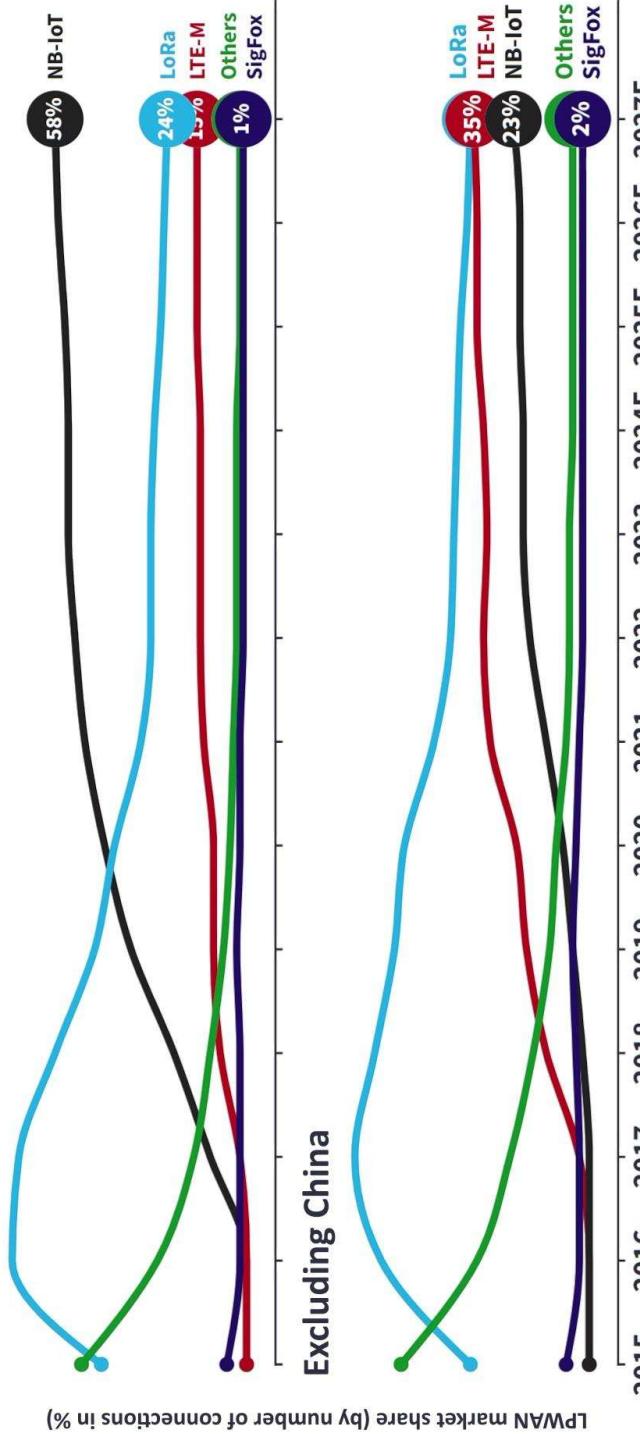
2

Copyright © 2018 by www.iot-analytics.com All rights reserved

2

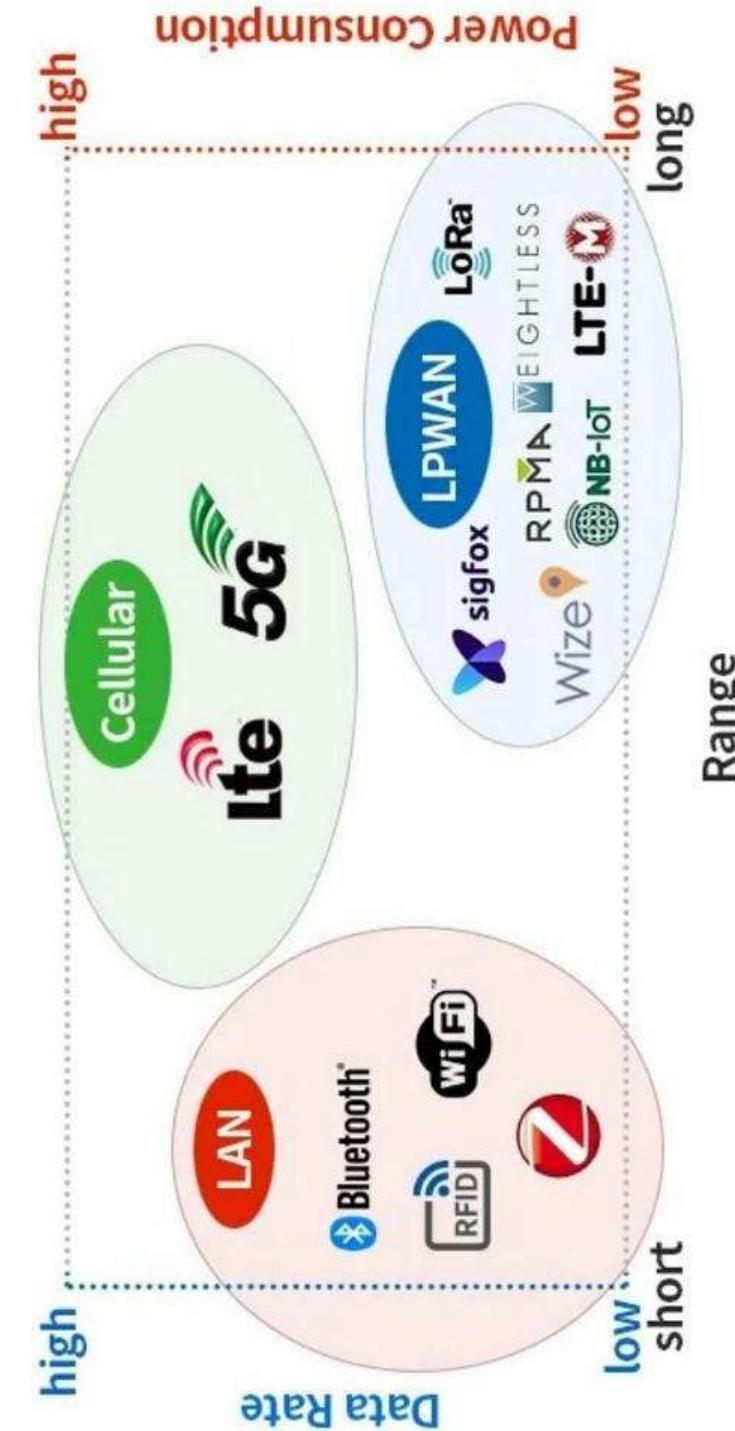


Global LPWAN market 2015-2027: Market shares of key technologies



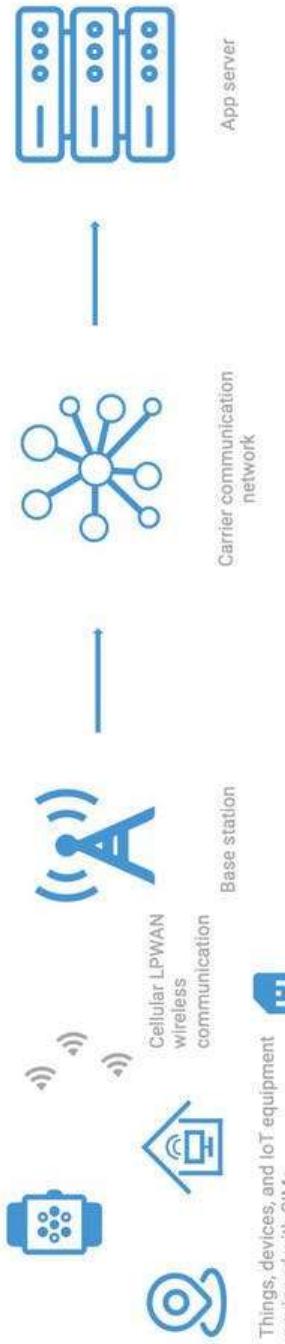
	Cellular	Non-Cellular
Available Technologies:	NB-IoT, LTE-M LoRaWAN, Sigfox	
Frequency	Set by the operator	Unlicensed ISM bands
Deployment requirements	Buy a package from a mobile operator	DIY based on local regulations
Data transfer rate	Faster	Slower
Mobility	Less mobile	More mobile
Cost per device	Cheaper	More expensive
Security	Standardized by 3GPP, centralized	AES-128, weak if setup improperly

<https://www.nexpcb.com/blog/nb-iot-fast-cheap-and-low-power>

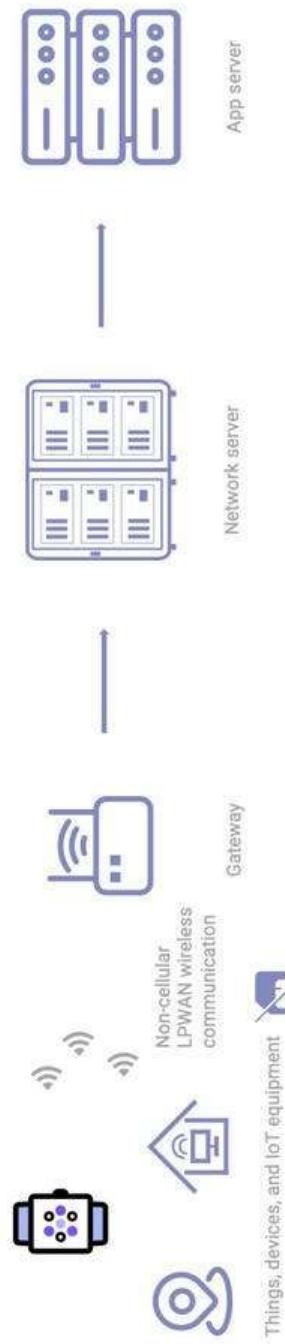


https://www.dfrobot.com/blog-17238.html?srsltid=AfmBOorPGLa7rafQDixqsrEAoy2WDdmK9zjA1sONAD0HWiiORQ_YVDb

Cellular LPWAN



Non-cellular LPWAN

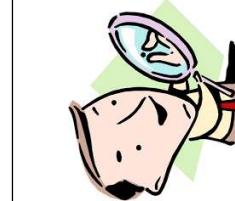
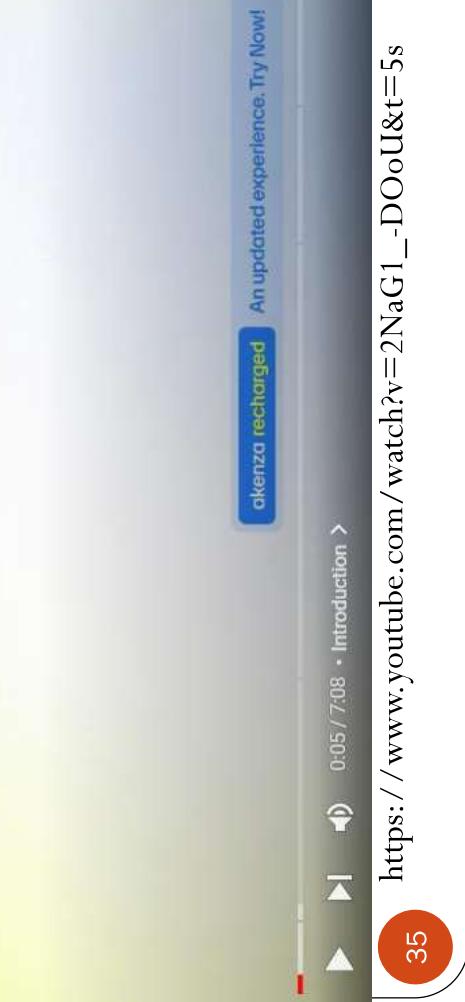


Feature	NB-IoT	LTE-M	Sigfox
Spectrum	Licensed	Licensed	Unlicensed
Range (Urban/Rural)	~1km / ~10km	~1km / ~10km	~5km / ~20km ~10km / ~40km
Data Rate	< 66 kbps (UL), < 26 kbps (DL)	1 Mbps	0.3-5.5 kbps 0.1 kbps
Battery Life	Years	Years	Years
Latency	1.2-10s	< 60ms	Seconds
Mobility Support	Limited	Yes	Yes
Private Networks	No	No	No (but can deploy own gateways)
Max Payload Size	1,280 bytes	1,280 bytes	12 bytes (UL), 8 bytes (DL)
Power Consumption	20-120mW	60-200mW	20-100mW

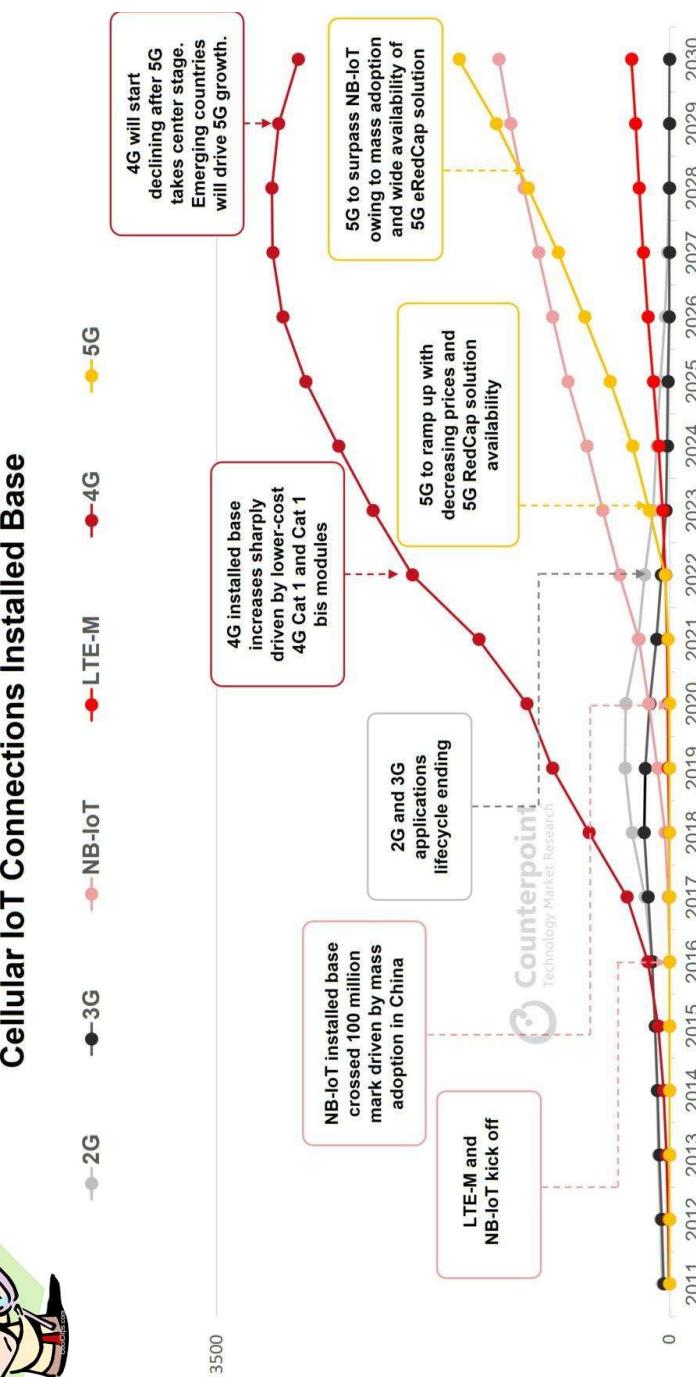
Cellular IoT



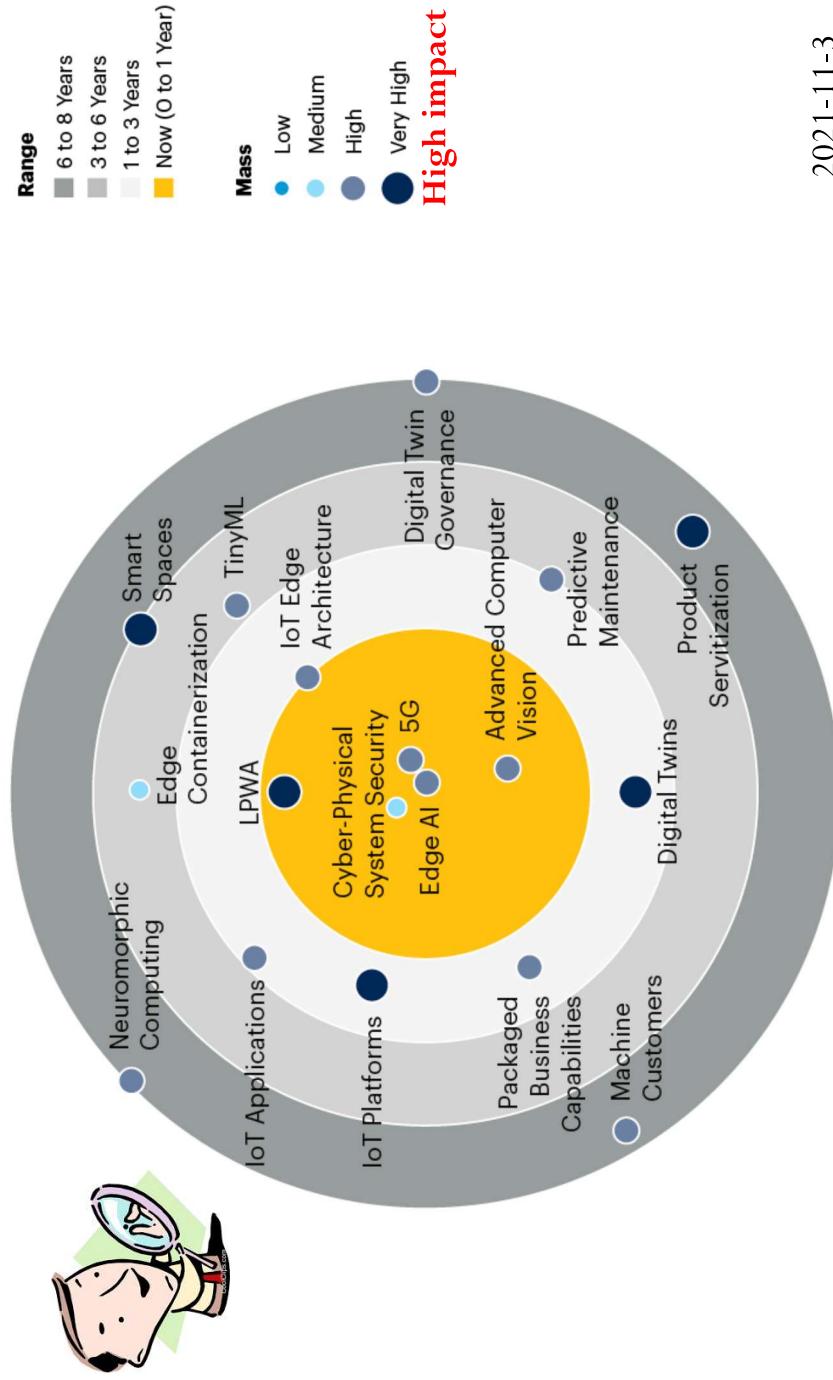
An introduction to cellular IoT



Cellular IoT Connections Installed Base (in million units)



Emerging Technologies and Trends Impact Radar: Internet of Things



Gartner



LPWAN百家爭鳴 IoT成長動能更強勁

2022-04-25 / 黃繼寬



對於物聯網應用而言，省電且涵蓋範圍夠大的無線聯網技術，是極為重要的關鍵技術。也因為如此，蘊含著龐大商機的低功耗廣域網路(LPWAN)技術，成為各路人馬積極投入的熱門領域。而隨著市場競爭的白熱化，目前市面上的LPWAN解決方案不僅越來越省電，同時在功能整合度、成本方面，也有長足的進展，並回過頭來為物聯網應用打開更多潛在的應用場域跟情境，形成產業發展的正向循環。

安全與低功耗為IoT應用共通需求

<https://www.2cm.com.tw/2cm/zh-tw/market/D20AFF8A078D4D15B8DC48CA198A782C>

晶片設計商 模組開發商 電信設備商 電信營運商



NB-IoT
NB-IoT

Qualcomm	Genalto	Ericsson	AT&T	China
Huawei	wireless	Nokia	Mobile	Deutsche
Intel	Telit	Huawei	Telekom	Verizon
Altair	Ublox		Vodafone	
Sequans	Sierra			
ARM	WNC			
ARM	Sercomm			

LoRa
LoRa

STMicroelectronics	Microchip	Advantech	AT&T	Sigfox
M2COMM	NXP	GREATECH	Unibiz	Ubiquisys
Microchip	TI	GMBH	Arqiva	Engie
			MTM	NetFrontier
			VT Network	



SIGFOX



LoRa



NB-IoT



LPWAN技術的主要晶片製造商



LPWAN技術特點

低功耗廣域網路 (Low Power Wide Area Network)

近幾年才開始商用化的物聯網通訊技術

主要針對M2M的通訊技術

遠距離、低功耗、低成本

未授權頻譜技術：LoRa、Sigfox、Weightless、Hallow

卷之三

庫識知經財

珊瑚
丁子
檳
十
441 / 10024

10

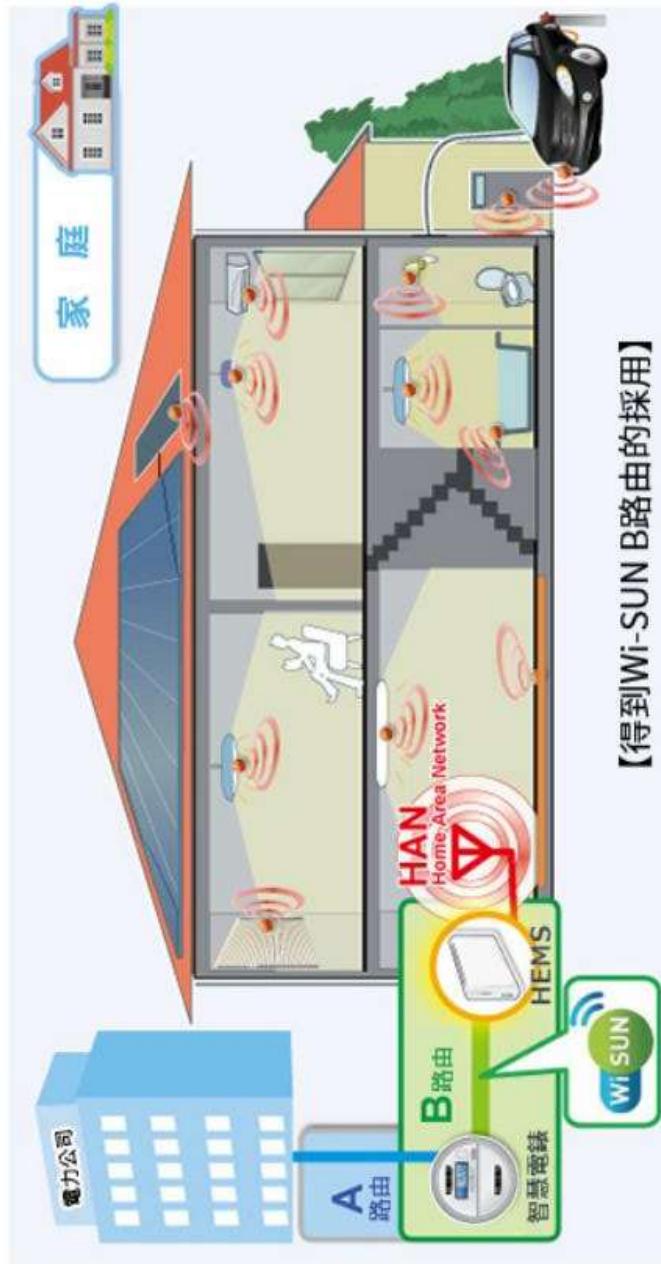
<https://tw.sports.yahoo.com/video/%E7%89%AA9%EE8%81%AF%EE7%BB2%EE9%80%9A%EE8%AA8%EE5%8D%94%EE8%AD%BB0%EE7%99%BE%EE5%AE%BB6%EE7%88%AD%EE9%BB3%BB4-%lpwan%EE5%BB8%EE83%EE5%BB1%EE80%EE6%EE88%EE90%EE5%BD%AA2-160000124.html>

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Wi-SUN

Wireless Smart Utility Network





- 使用 **920MHz** 頻段，與使用 2.4GHz 和 5GHz 頻段的 Wi-Fi 相比，雖然通信速度較慢，但具有**通信距離長、可繞過障礙物且易接通、低功耗**的優點。
- 日本的電力公司已採用 Wi-SUN 作為**智慧電錶**和家庭內 **HEMS** (Home Energy Management System) 之間的路由通信標準。

43



Wi-SUN智慧路燈應用案例

44



Illuminating London's historical heartland

<https://www.youtube.com/watch?v=3nQDSqx3S3w&t=7s>

45



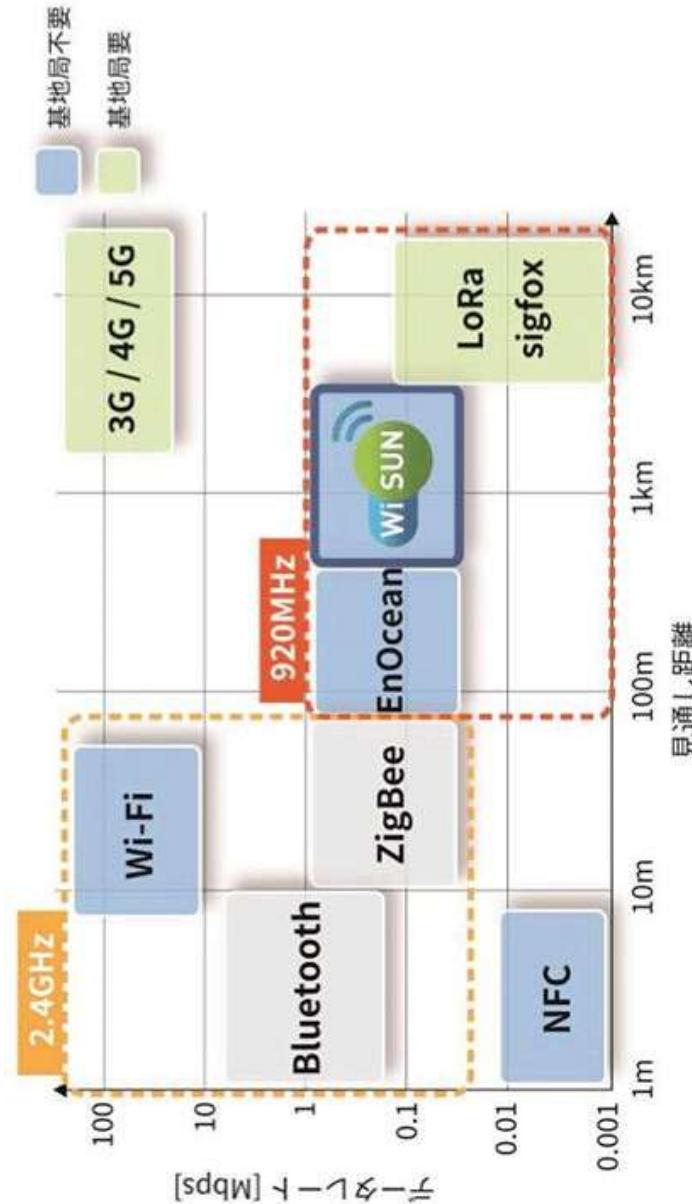
Parameters	Wi-SUN	LoRaWAN	NB-IoT
Frequency	< 1 GHz and 2.45 GHz	863 to 870 MHz, 902 to 928 MHz, 779 to 787 MHz ISM bands Refer LoRa Frequency Bands >> for more information.	700MHz, 800MHz, 900MHz, 1700 MHz, 1800 MHz and 1900 MHz Refer LTE NB-IoT Frequency Bands >> used in different countries.
Data rate	Up to 300 Kbps	0.3 to 22 Kbps (LoRa modulation) and 100 Kbps (using GFSK)	Up to 60 Kbps in Cat. NB1 and up to 158 Kbps in cat NB2
Latency	0.02 to 1 sec	1 to 2 sec	1.4 sec to 10 sec
Encryption for Data transmission	AES, HMAC, Certificates	AES, CMAC, Pre-shared secret	LTE data transmission encryption, AES
Coverage range	4 km point to point using 1W output from non-directional antenna	2.5 Km (urban areas), 15 Km (suburban areas)	1 km (urban), 10 km (rural)
Power consumption	2μA (while at rest), approx. 8mA (during listening), < 14mA at +10dBm (during transmission)	Best at very low data rates, Battery life is extended in PSM or eDRX modes, current consumption is about 2 to 3 μA in PSM mode.	Very low power consumption and hence extends battery life to 10 years
Preferred application	Designed for frequent communication up to 10 seconds	Designed for infrequent communication up to 128 seconds	Designed for infrequent communication up to 600+ seconds

<https://www.rfwireless-world.com/Terminology/Wi-SUN-vs-LoRaWAN-vs-NB-IoT.html>

46

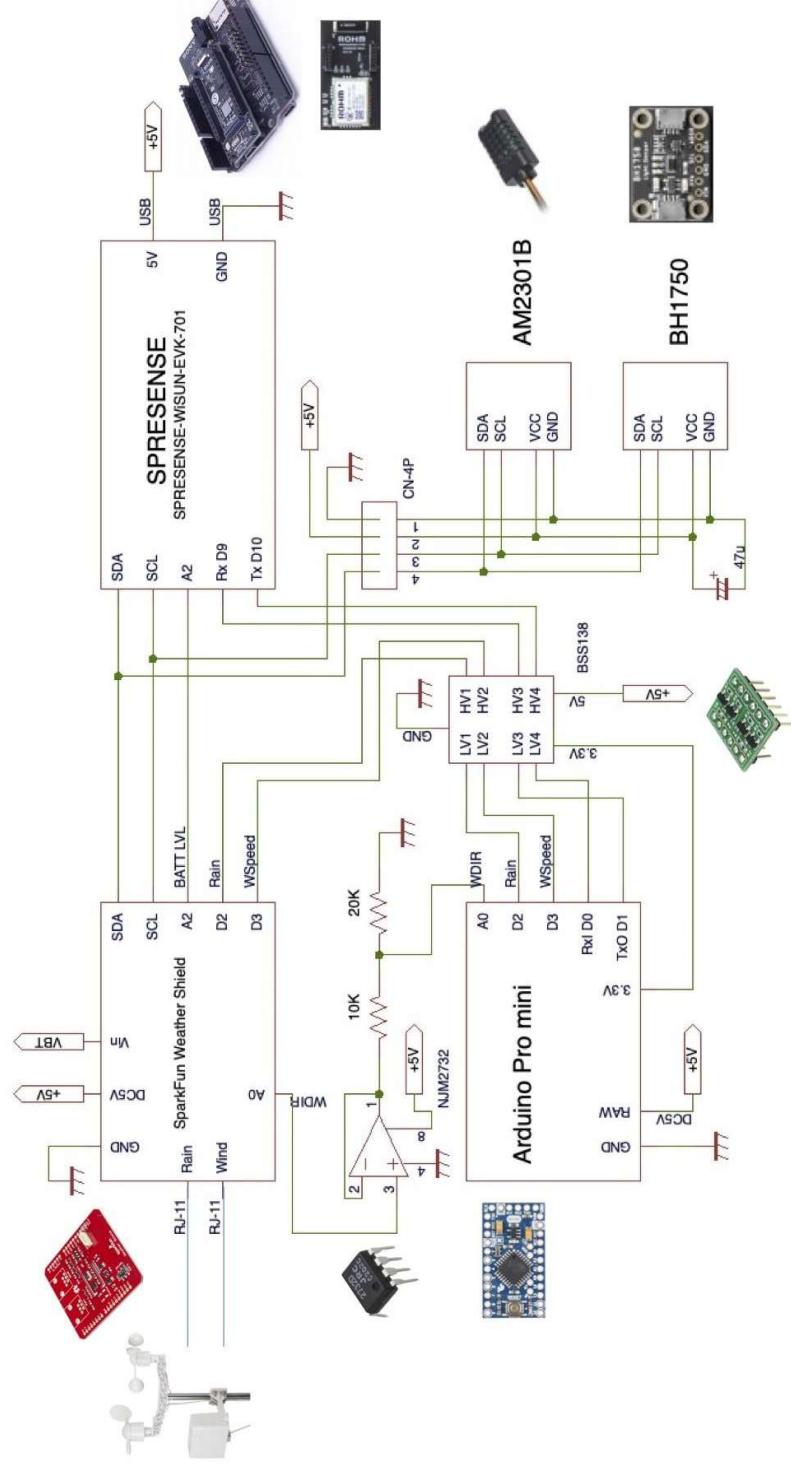
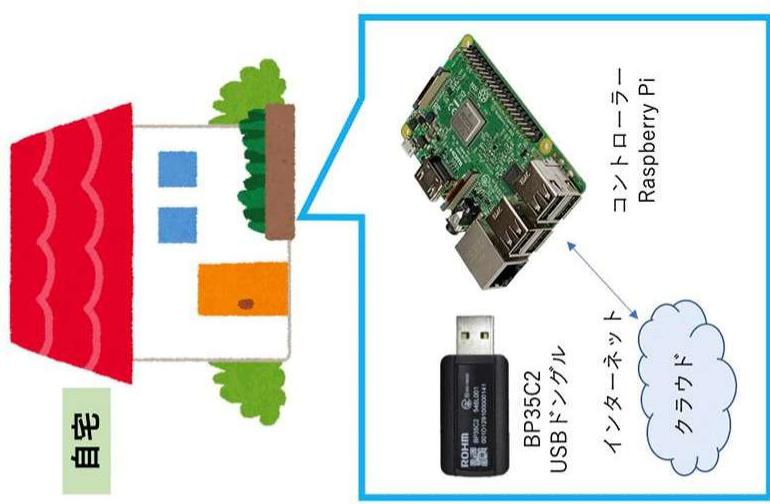
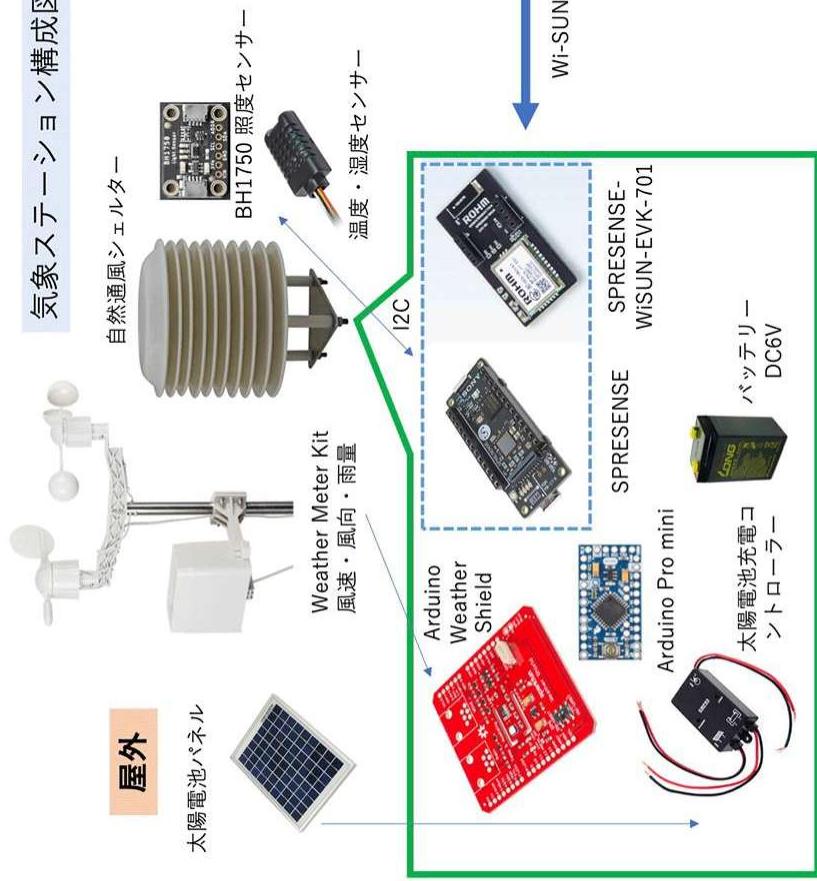
Aspect	Wi-SUN	NB-IoT
Technology	Mesh networking standard for IoT and smart utility applications	Cellular-based LPWAN technology
Deployment	Deployed in various IoT and smart utility networks	Primarily used for IoT applications, often in cellular networks
Spectrum	Operates in sub-GHz frequency bands	Operates in licensed cellular spectrum bands
Coverage	Offers extensive coverage, suitable for wide-area deployments	Provides good coverage in urban areas, may lack in rural areas
Power Consumption	Optimized for low power consumption	Optimized for low power consumption, suitable for battery-operated devices
Data Rate	Supports moderate data rates	Supports low to moderate data rates
Scalability	Highly scalable, suitable for large-scale deployments	Supports a large number of devices per cell
Interoperability	Certified by the Wi-SUN Alliance for compliance with interoperability standards	Standardized by 3GPP, certified devices ensuring interoperability
Security	Incorporates advanced security features	Provides robust security mechanisms

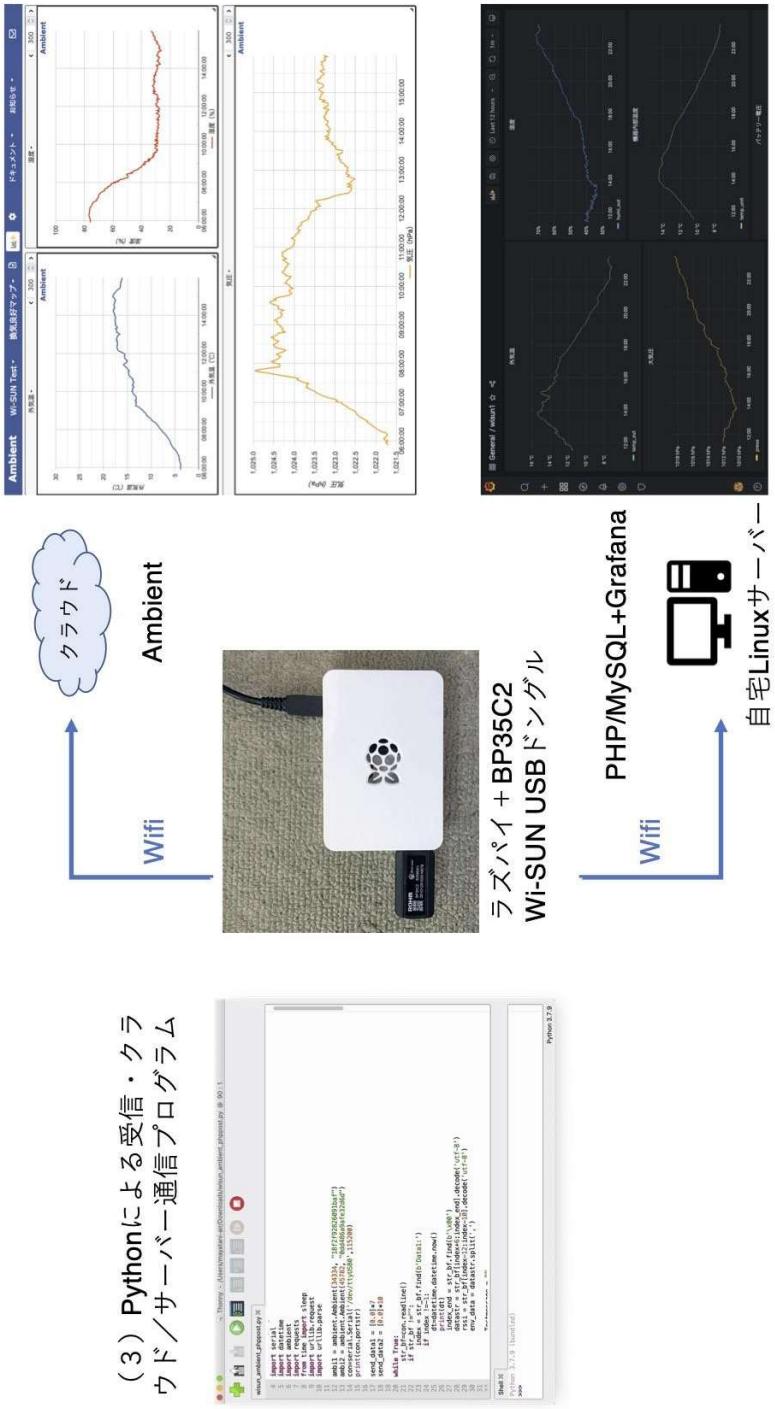
47



48

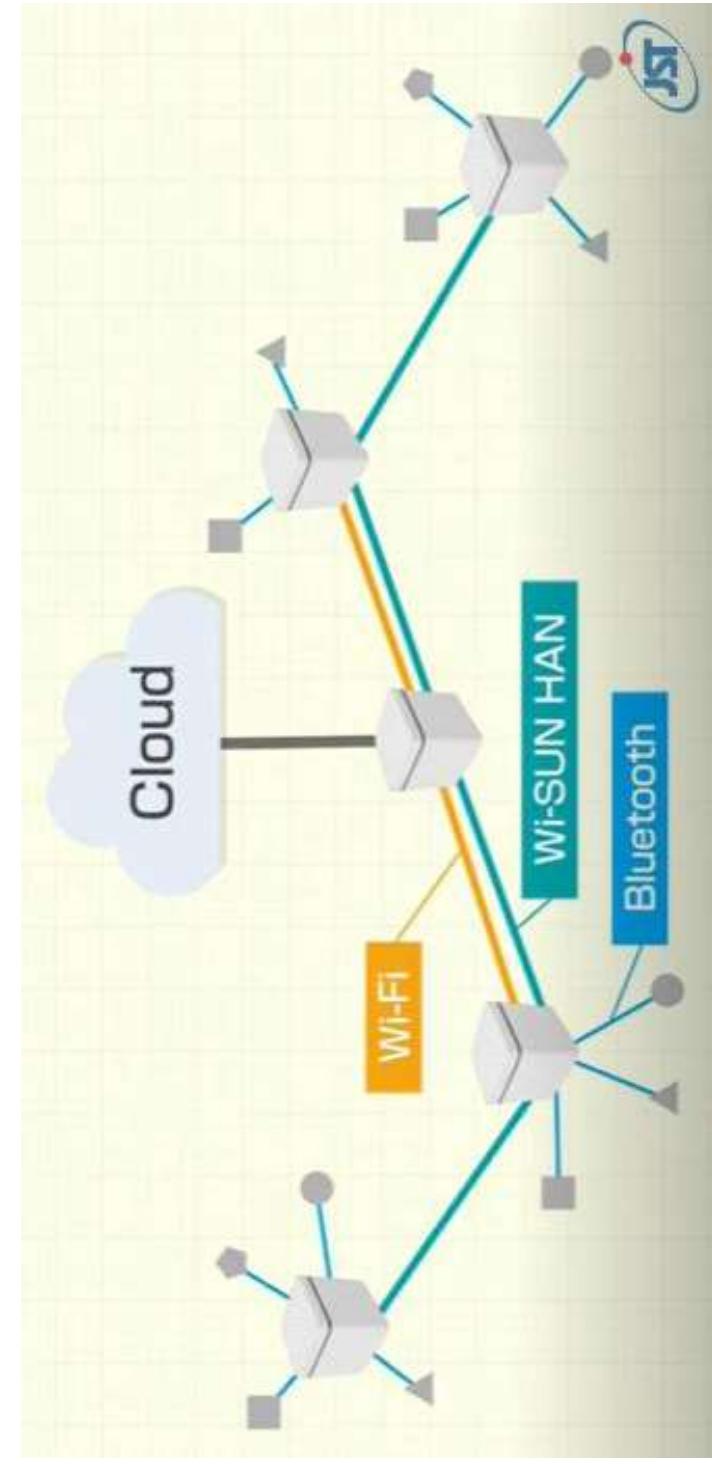
気象ステーション構成図





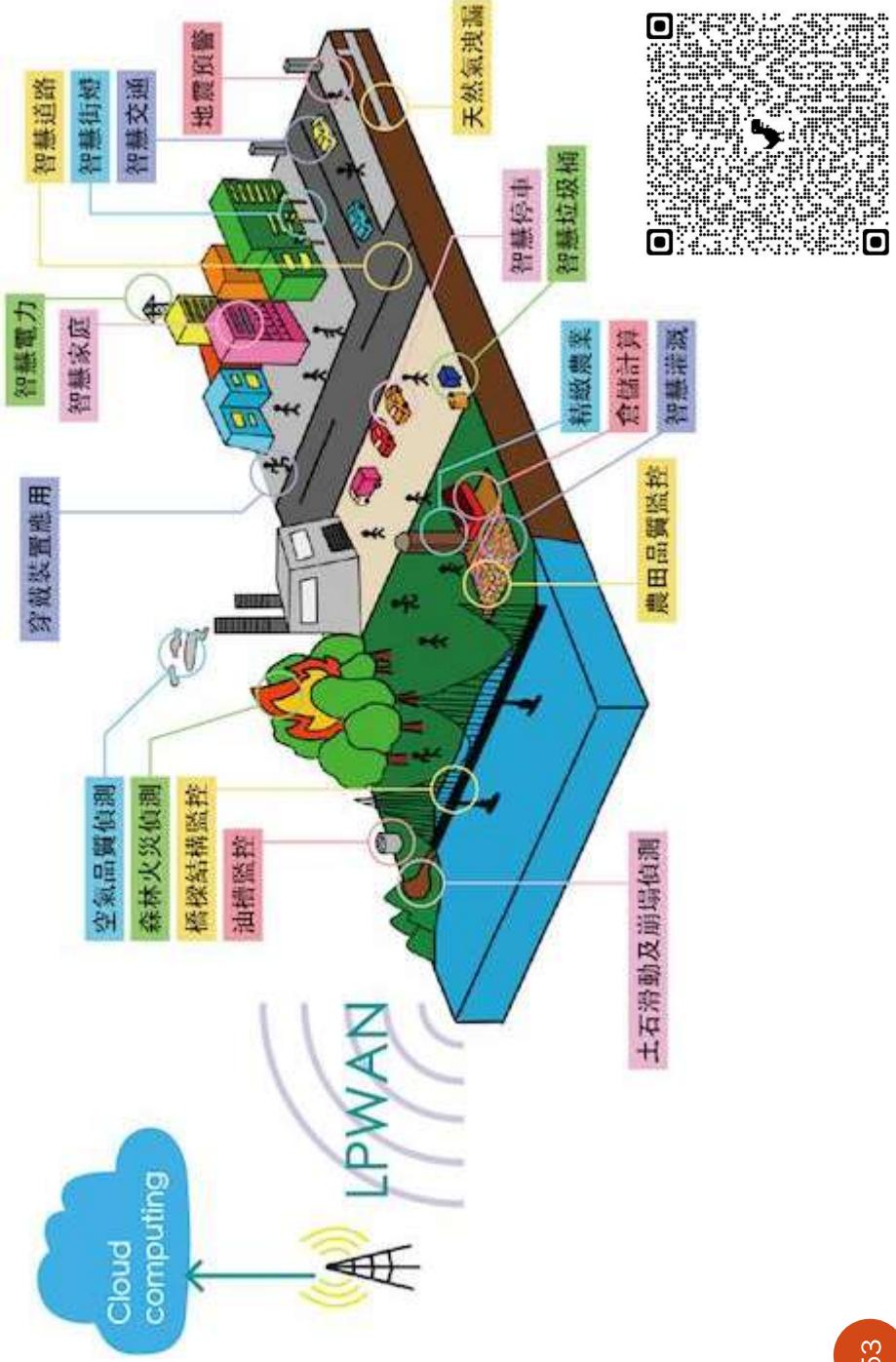
<https://deviceplus.jp/mc-general/weather-station-with-wisun-03/>

Predictive health care realized by using ultra-big data with connected medical devices



<https://www.youtube.com/watch?v=yEcUIE1awTxU&list=PL7FfWNmyxG2XSILjtykDg67ZOwyo5FOa5>

LPWAN多元的應用情境示意



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百家爭鳴、何者勝出？

Olivier Hersent · 3rd
CEO & CTO at Actility



LoRa創始人之一—Olivier Hersent曾說：
互相合作的共存關係更可能帶領未來技術走向新的發展。

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	Sigfox	LoRa	NB-IoT
創立年	2009年	2015年	2016年
主要推動者	Sigfox（公司）	LoRa Alliance（聯盟）	3GPP（聯盟）
使用頻譜	非授權頻譜 Sub-1GHz ISM	非授權頻譜 Sub-1GHz ISM	1GHz以下之授權頻譜 (營運商)
使用頻寬	100Hz	125-500kHz	180kHz
最遠傳輸距離	50公里	20公里	20公里
傳輸速率	100bps（低）	300bps-50kbps (中)	50kbps（高）
可連接數量	100萬	25萬	10萬
優勢	1. 傳輸距離最長 2. 功耗較低 3. 提供現有Sigfox基地台及雲端平臺 4. 全球性網路服務	1. 營運成本低 2. 功耗較低 3. 資料傳輸速率彈性運作 4. 可與多個電信營運商合作	1. 使用授權頻譜，干擾較小 2. 可維持穩定連線品質 3. 可使用現有4G電信基地台 4. 無限制傳輸限制

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https://www.ibtmag.com.tw/new_article_result.asp?secu_id=HCP011&search_security_id=25557

Aspect	NB-IoT	LoRa
Technology	Cellular-based technology standardized by 3GPP	Proprietary modulation technology developed by Semtech
Deployment	Utilizes existing cellular infrastructure	Requires deployment of LoRa gateways and LoRaWAN networks
Spectrum	Operates in licensed spectrum bands	Operates in unlicensed ISM bands (e.g., 868 MHz, 915 MHz)
Coverage	Good coverage in urban areas, indoor penetration	Long-range communication, suitable for wide area coverage
Power Consumption	Optimized for low power consumption	Designed for low power consumption, long battery life
Data Rate	Supports low to moderate data rates	Supports variable data rates, from low to high
Scalability	Supports a large number of devices per cell	Highly scalable, LoRaWAN networks can support thousands of devices
Interoperability	Standardized by 3GPP, certified devices ensuring interoperability	LoRaWAN certification ensures interoperability
Security	Provides robust security mechanisms	Offers security features such as encryption and authentication
Cost	Typically associated with cellular service plans	Generally lower deployment costs due to unlicensed spectrum and simpler infrastructure

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表1、三大LPWAN技術比較

技術協定	主要推動者	規格推出年份	基地台連接數量	使用頻段	傳輸距離	傳輸速度	頻寬	覆蓋率	基地台	功耗	通訊安全	連線干擾
Sigfox	SIGFOX (公司)	2009	100萬個 (高)	ISM Band Sub-1GHz (非授權頻段)	市區10km 郊區50km (高)	100bps(低)	100Hz	160dB	自行架設	>10年	低	大
LoRa	Semtech IBM Cisco (聯盟)	2015	25萬個 (中)	ISM Band Sub-1GHz (非授權頻段)	市區3km 郊區15km (低)	300bps-50kbps(中)	125-500kHz	157dB	自行架設 (可分公網與私網)	10年	低	大
NBIoT	3GPP (聯盟)	2016	10萬個 (低)	GSM or LTE Band、LTE Guard band (授權頻段)	25km (中)	50kbps(高)	180kHz	164dB	使用現行4G基地台	>10年	極高	極小

(資料來源：智慧城市鄉計畫辦公室、新通訊元件雜誌，本電子報再製)

Feature	NB-IoT	LTE-M	LoRa	Sigfox
Standard	3GPP	3GPP	Proprietary	Proprietary
Spectrum	Licensed	Licensed	Unlicensed	Unlicensed
Range	Medium to Long	Medium to Long	Long	Long
Data Rate	Low	Medium to High	Low	Low
Power Consumption	Low	Low	Low	Low
Scalability	High	High	High	High
Global Coverage	Yes	Yes	Regional/Global	Regional/Global
Security	Strong	Strong	Moderate	Moderate
Cost	Moderate to High	Moderate to High	Low	Low
Typical Use Cases	Smart Meters, Asset Tracking	Vehicle Tracking, Wearables	Smart Agriculture, Smart Cities	Asset Tracking, Smart Metering

Smart Metering FOR INDUSTRY

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<https://www.youtube.com/watch?v=7MPr6SDxFM4>



Two Leading LPWA Technologies

NB-IoT

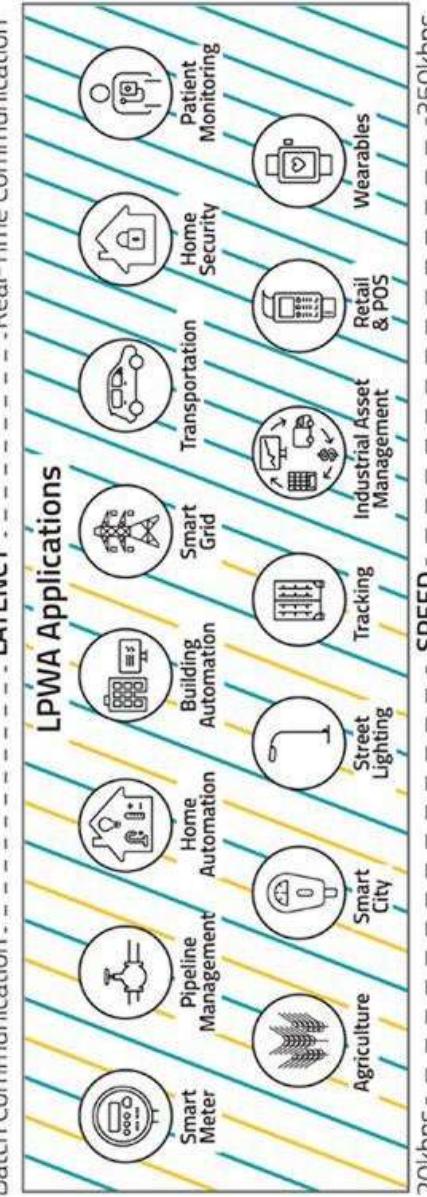
- Focused on very low data rates
- Ideal for simpler static sensor applications

LTE-M / eMTC / Cat-M

5G ready

- Highest bandwidth of any LPWA technology
- Ideal for fixed and mobile applications

Batch Communication - - - - - Real-Time Communication



<https://www.digitalmatter.com/5g-gps-trackers-cellular-iot/>

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3GPP

- 3GPP
 - 3rd Generation Partnership Project
 - 第三代合作夥伴計畫
 - 最初：團結全球通信夥伴，合作研究和制定3G（第三代移動通信技術）標準
 - 現況：3G → 4G → 5G



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3GPP第一版5G標準制定完成

- NB-IoT
 - 不限制傳輸訊息次數，能攜帶的資料量高
 - 重視網路傳輸穩定性與即時性，適合高資料傳輸的裝置
 - 功耗較高，電池壽命的損耗較大
- LoRa
 - 硬體成本低、功耗小、
 - 適合在小資料量、大範圍的傳輸應用
 - 傳輸距離不比Sigfox，但傳輸頻寬較高
 - 適合在高科技廠區封閉型網域，傳輸各類型的感測數據
- Sigfox
 - 硬體成本低、功耗小、
 - 提供全球性的網域及雲端服務，對跨國公司來說更為便捷
 - 傳輸距離最遠，但傳輸次數最少，適合應用在反應數據變化較小或固定時段傳送資料的場景

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蜂巢式物聯網會成為LPWAN的未來嗎？

Cellular LPWAN

◎ 作者：Nordic Semiconductor供稿

■ 類別：專家觀點

2022-12-02

(0) 評論



隨著競爭技術面臨諸多困難，蜂巢式物聯網技術被視為連接終端設備和雲端的橋樑...

市場分析機構IoT Analytics指出，儘管受到新冠疫情和相關晶片短缺的影響，LPWAN市場仍然穩定成長，在2020年支持了全球4.5億個LPWAN活躍設備的裝機量，到2021年底將擴大到約6.6億個。

<https://www.eettaiwan.com/20221202nt71-is-cellular-iot-the-lpwan-of-the-future/>

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儘管LPWAN市場仍然分散，但蜂巢式物聯網(cellular IoT)技術NB-IoT和LTE-M正在搶佔最大的市佔率。根據市場分析機構Juniper Research的《蜂巢式物聯網：2022~2026年策略、機遇和市場預測》(Cellular IoT: Strategies, Opportunities & Market Forecasts 2022-2026)報告，預計NB-IoT和LTE-M在未來4年內的裝機量將急劇成長1,200%。這家分析機構認為，連接和硬體成本的相對低廉，是推動遠端監控應用採用蜂巢式物聯網的關鍵驅動因素。

根據IoT Analytics報告，NB-IoT(47%)和LTE-M(10%)已佔據全球LPWAN裝機量的57%，而其他LPWAN競爭技術共計佔據的比例是43%。報告顯示，豐富的生態系統支援(包括Amazon、Arm、Cisco、華為和Qualcomm等主要物聯網供應商，以及Vodafone、Orange和西班牙電訊等網路營運商)共同促成了這個成果。

蜂巢式物聯網市場成長看起來很樂觀，其他競爭技術又如何呢？在物聯網領域，LoRaWAN佔有36%的市佔率，Sigfox佔3%，其他技術佔4%。然而，最近法國的業務突變情況顯示，至少在目前，這些市佔率仍然不穩定。例如，據報導法國領先的行動電訊供應商Bouygues Telecom正計畫從2024年起關閉在法國的LoRaWAN網路，並計畫將業務轉向蜂巢式物聯網網路。

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蜂巢式物聯網提供端到端IP連接，隨著這類網路基礎設施在美國、歐洲、中國、澳大利亞和其他區域推出，這項技術廣受青睞。每個基地台可以支援多達50,000個蜂巢式物聯網連接，通訊是完全雙向、穩健、可靠和安全的，並且該技術已在3GPP的Release 15版本納入成為5G規範的一部分。

蜂巢式物聯網的基礎設施投資龐大，但擁有堅實的全球標準機構、強大的網路營運商和龐大的供應商生態系統支援，所以這些投資是物有所值。



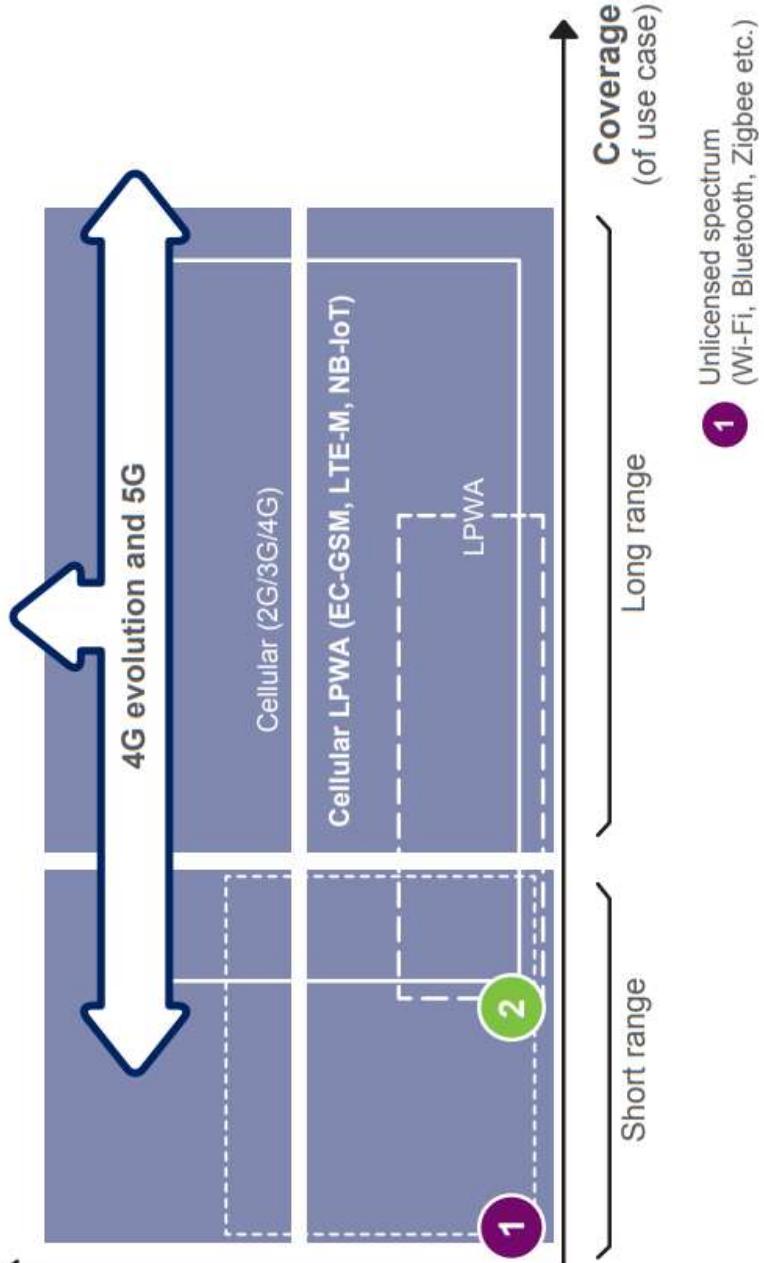
CELLULAR NETWORKS FOR MASSIVE IOT

ENABLING LOW POWER WIRELESS APPLICATIONS

With new standards specifically targeting the connectivity requirements of Massive Internet of Things (IoT) applications, cellular networks can deliver reliable, secure and diverse IoT services using existing network infrastructure.

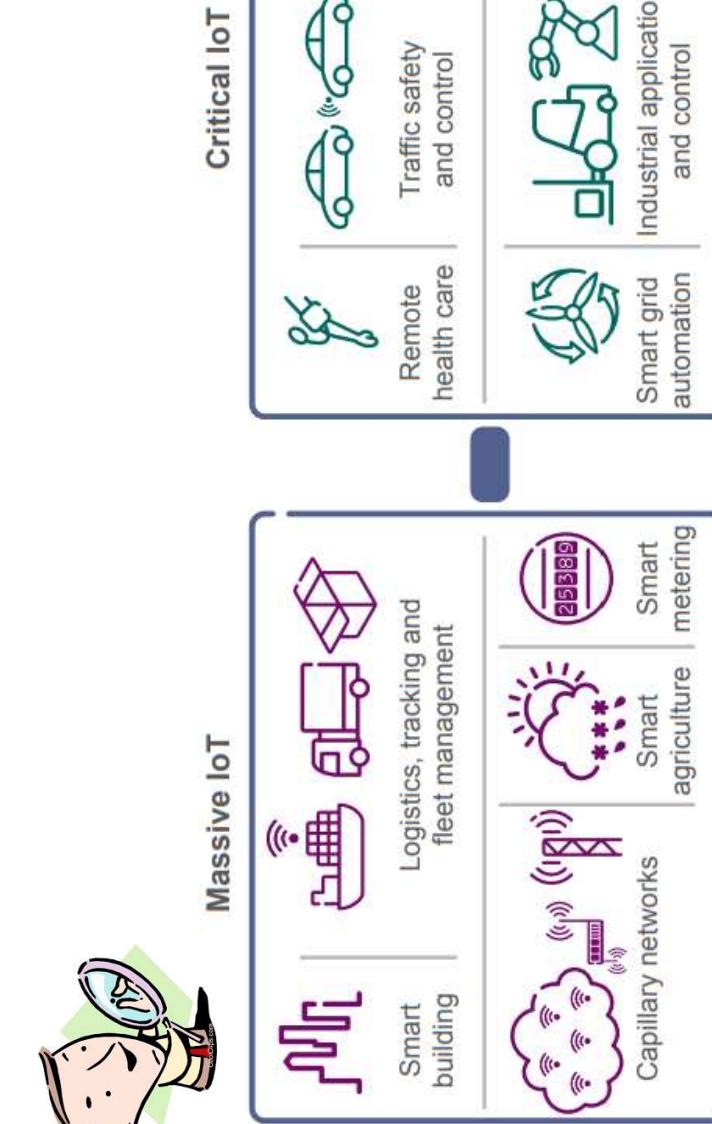
https://www.ericsson.com/4ada75/assets/local/reports-papers/white-papers/wp_iot.pdf

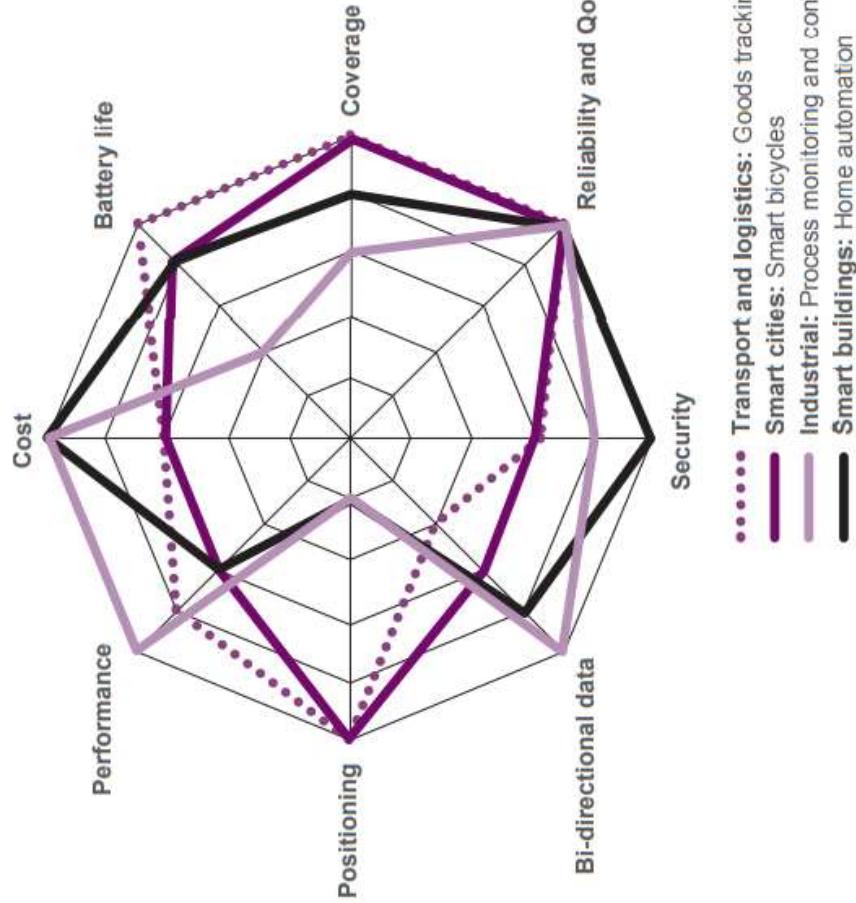
Performance



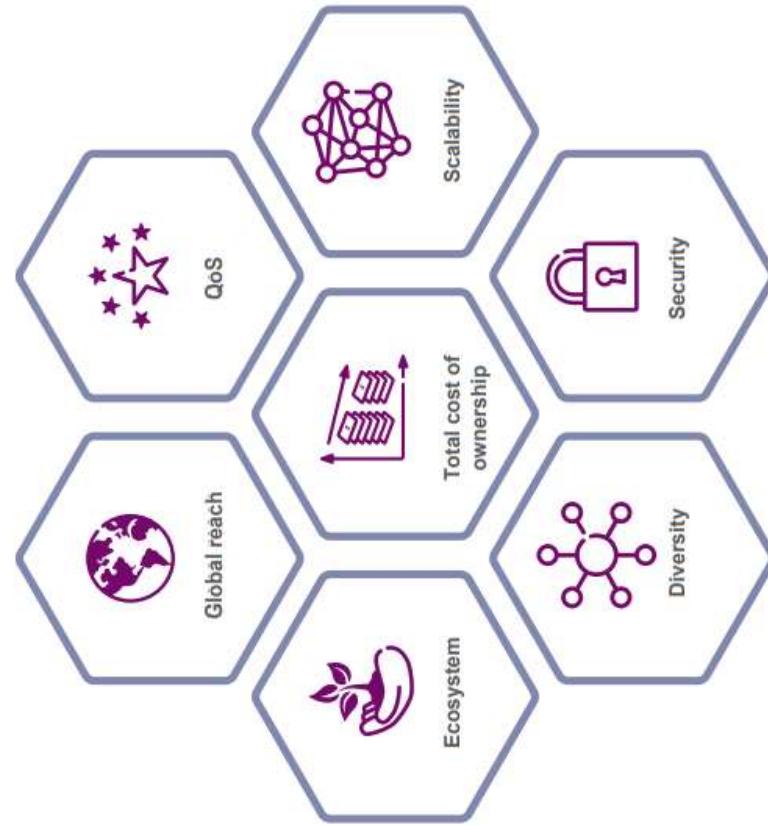
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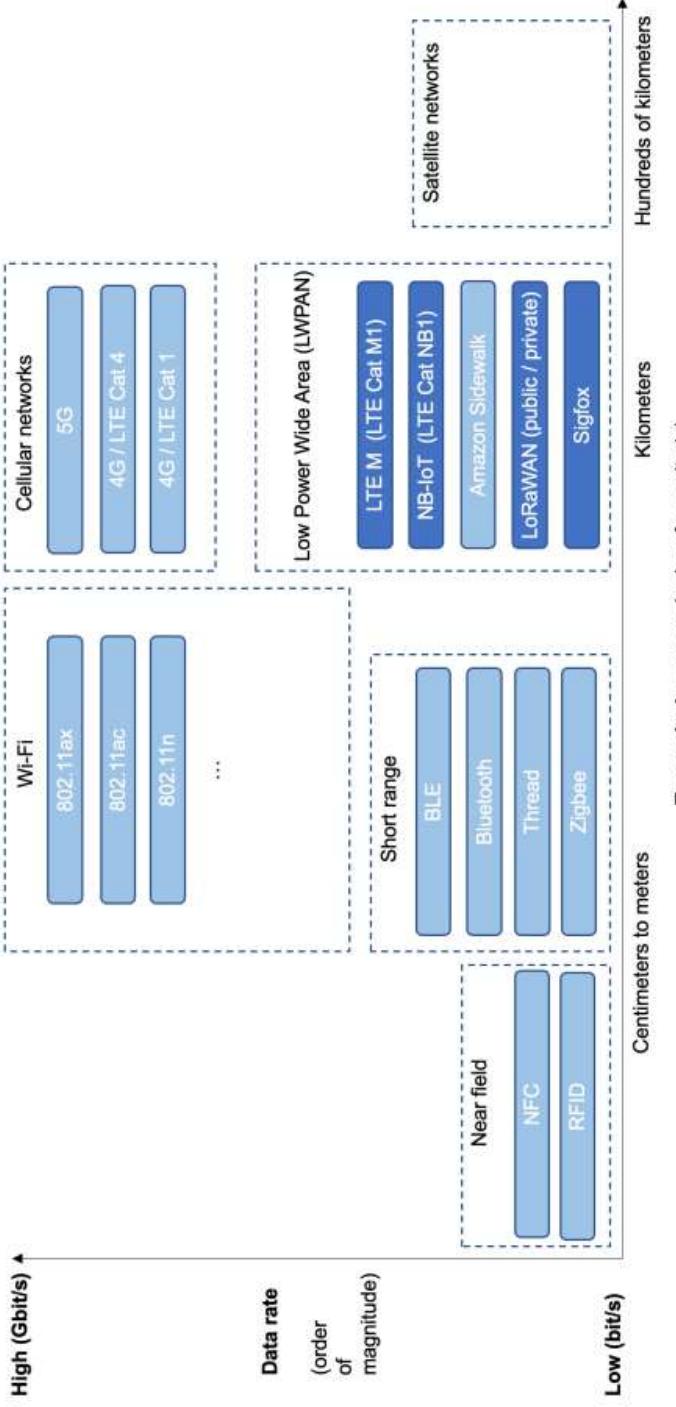
70

Implementing Low-Power Wide-Area Network (LPWAN) Solutions with AWS IoT

AWS Whitepaper

<https://docs.aws.amazon.com/pdfs/whitepapers/latest/implementing-lpwan-solutions-with-aws/implementing-lpwan-solutions-with-aws.pdf#nb-iot>

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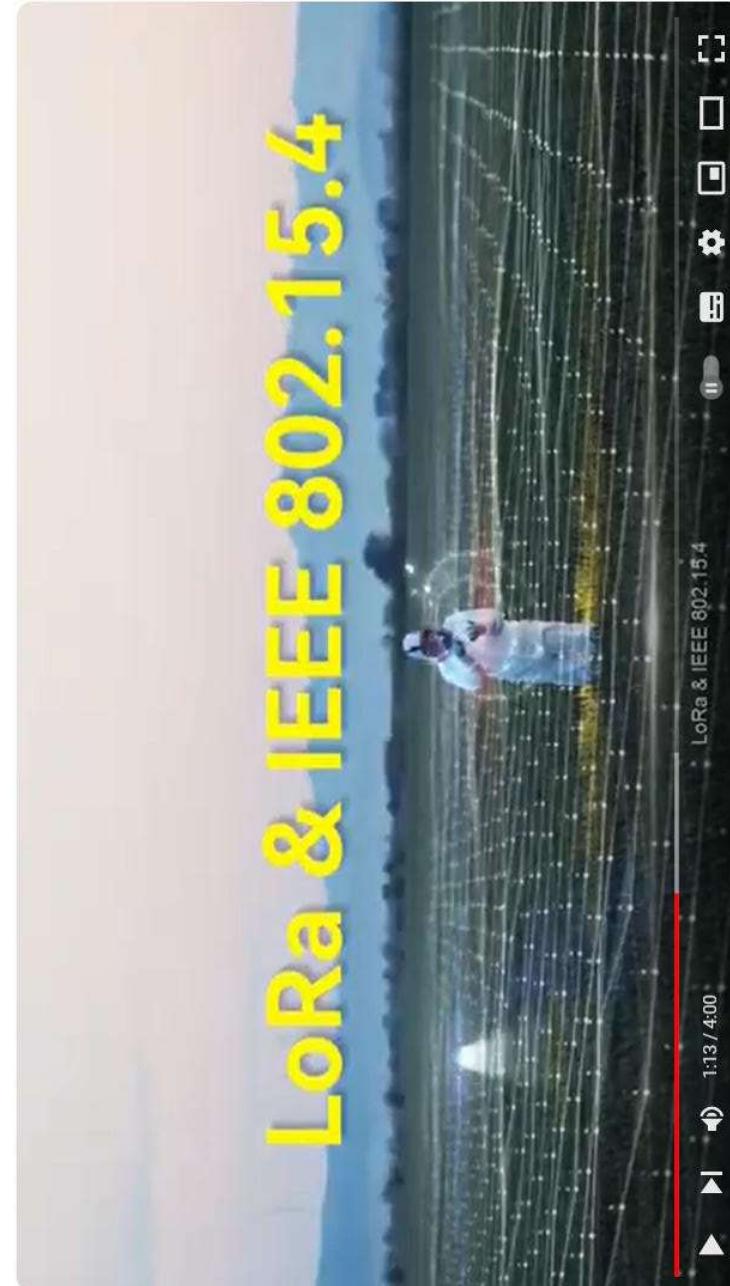
Connectivity technologies overview

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Technology	LoRaWAN	NB-IoT (LTE Cat NB1)	LTE-M (LTE Cat M1)	Sigfox
Range and coverage	~5 km urban km rural	~1 km urban ~10 km rural	~1 km urban ~10 km rural	~10 km urban ~40 km rural
Support for device mobility	Yes	Limited	Yes	Yes
Uplink latency (order of magnitude)	Seconds	1.2-100 s	< 60 ms	Seconds
Data rate	0.3 (SF12)-5.47 (SF7) kilobit/s	< 66 kilobit/s (uplink) < 26 kilobit/s (downlink)	1 megabit/s	0.1 kilobit/s
Allow private networks	Yes	No	No	No (however, customers can deploy their own gateways)
Battery life and power consumption	Years (when operating as a Class A device)	Years (when using eDRX and PSM features)	Years (when using eDRX and PSM features)	Years
Maximum payload size	11-242 bytes, depending on regional regulations and spread factor	1,280 bytes recommended	1,280 bytes recommended	1-2 bytes (uplink) 8 bytes (downlink)
Support for indoor and underground coverage	Yes	Yes	Yes	Yes
Reachability	Depends on device class (high for Class A, low for Class C)	Depends on power saving model configuration (PSM/eDRX)	Depends on power saving model configuration (PSM/eDRX)	High (downlink transmission allowed only during 30 seconds after uplink)
Licensed spectrum	No	Yes	Yes	No
Maximum messages per day	Depends on regional regulations of duty cycle	Unlimited	Unlimited	140 per day (uplink) 4 per day (downlink)

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Comparison of LoRa and Other LPWAN Technologies



Comparison of LoRa and Other LPWAN Technologies

<https://www.youtube.com/watch?v=n4gLfh7Prs&t=240s>

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IoT Protocol

- Why IoT Protocols Matter
 - Allow interoperability, Reduce IoT fragmentation, Minimize security risks, Improve ability to troubleshoot issues
- Data Protocol
 - Transmission Control Protocol/ Internet Protocol (**TCP/IP**) , Message Queuing Telemetry Transport (**MQTT**) , Data Distribution Service (**DDS**) , HyperText Transfer Protocol (**HTTP**) , Constrained Application Protocol (**CoAP**) , Advanced Message Queuing Protocol (**AMQP**) , Extensible Messaging and Presence Protocol (**XMPP**), ...
- Network Protocol
 - Cellular, Bluetooth, Wi-Fi, LoRa, Zigbee, Z-Wave, ...

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<https://www.zipitwireless.com/blog/iot-protocols-and-standards-an-introductory-guide>

Your Global IoT Market Research Partner

IoT ANALYTICS

5 things to know about IoT protocols

- 1  There is no one-size-fits-all IoT protocol
無一體適用協定
- 2  Protocols purpose-made for IoT are seeing increased adoption **MQTT, CoAP**
特定目的導向
- 3  Software is becoming more important to managing IoT connectivity
裝置聯網管理
- 4  "Ease of use" and "reliability" are most important when choosing a new protocol
便利及可靠
- 5  Decision making for IoT protocols has become a multi-stakeholder exercise
多方利益競逐

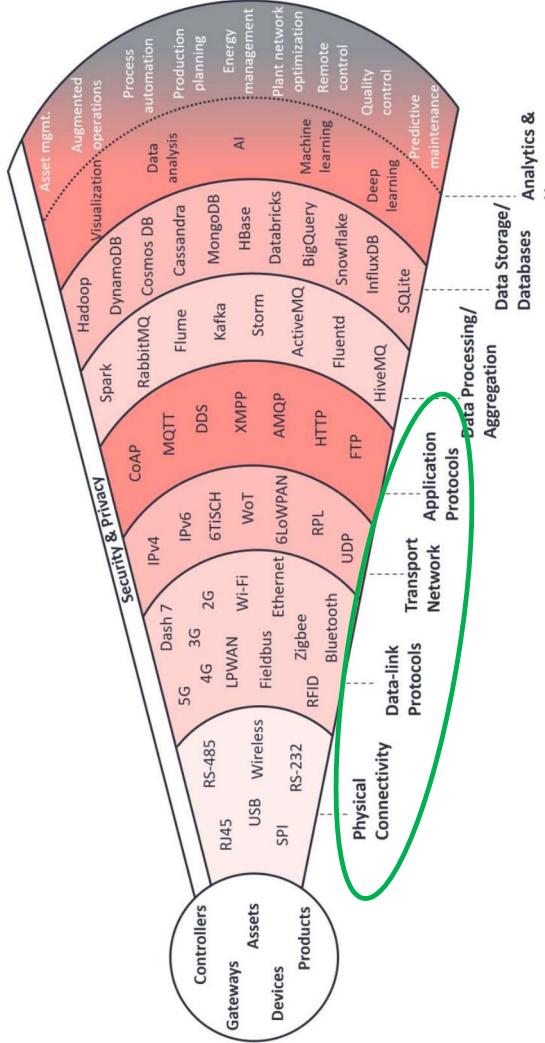
Source: IoT Analytics Research 2022. We welcome republishing of images but require source citation with link to original post and company website.

<https://iot-analytics.com/iot-protocols/>

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The IoT protocol landscape: From device to applications



MQTT

Established 1999 (2013 OASIS standard)

Messaging Pattern Publish/subscribe via message broker

2014

Request/response (client-server)

Transport Transmission Control Protocol (TCP)

SSL/TLS over TCP

User Datagram Protocol (UDP)

DTLS over UDP

Security

Broker architecture can simplify management; TCP and quality of service overhead UDP; RESTful model is welcoming to options enable robust message delivery developers and provides for integrated resource discovery

Fast and efficient due to reliance on low-

Weaknesses Always-on TCP connections limit utility for low-power devices; SSL/TLS encryption a poor match for constrained clients

Lacks the reliability and service guarantees of

TCP-based MQTT

CoAP

Established 2014

Messaging Pattern

Request/response (client-server)

Analytics & Use cases

Data Storage/ Databases

Asset mgmt. Augmented visualization-operations

Process automation planning

Production planning

Energy management

Plant network optimization

Machine learning

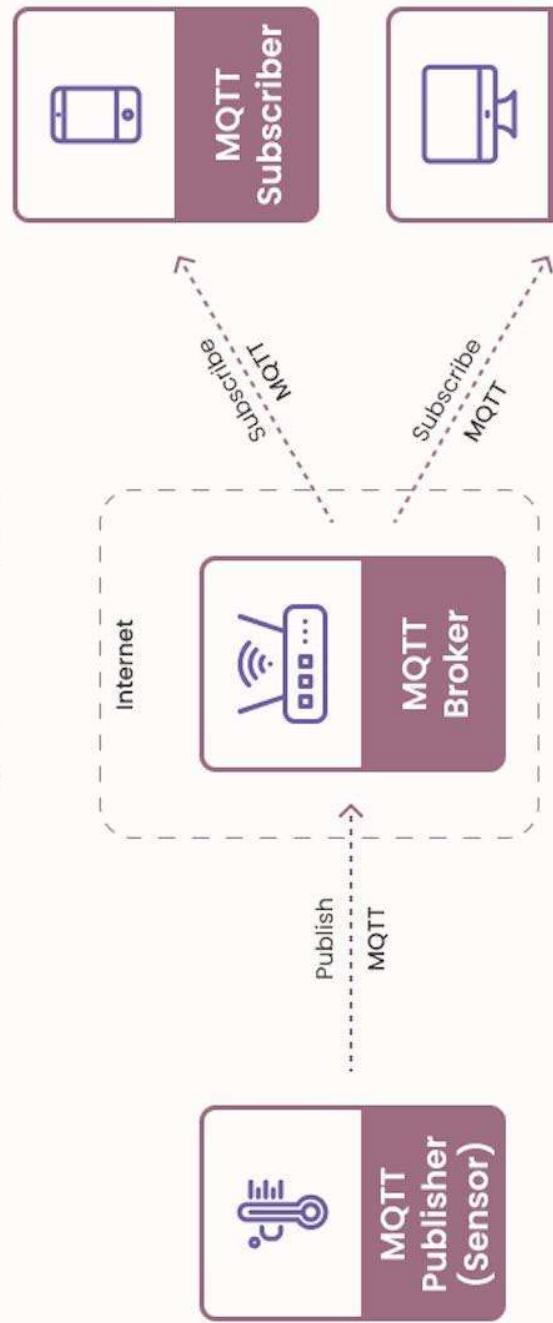
Remote control

Quality control

Predictive maintenance

MQTT Protocol

Intuz

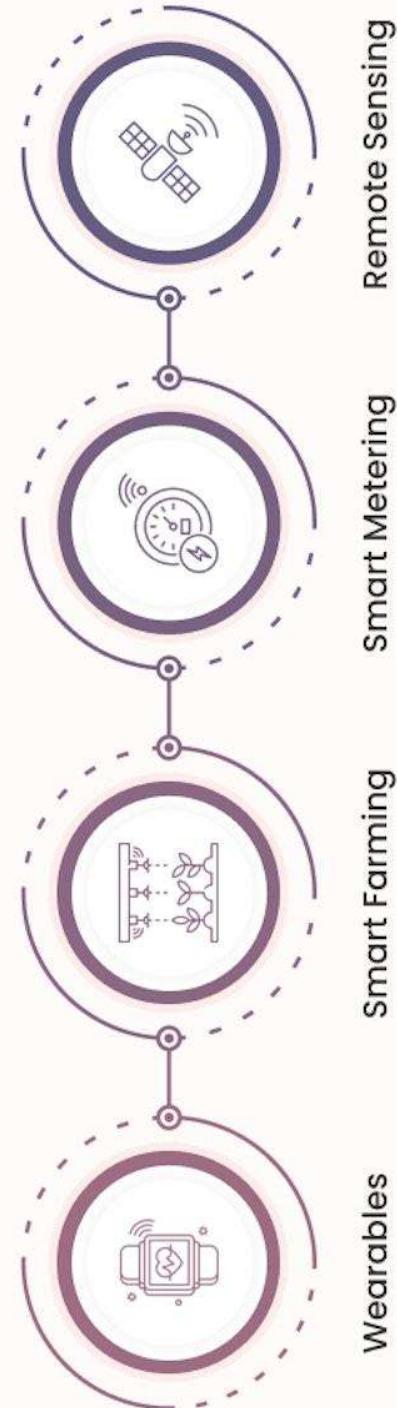


<https://www.intuz.com/blog/mqtt-vs-coap>

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Use cases of MQTT

Intuz



Remote Sensing

Smart Metering

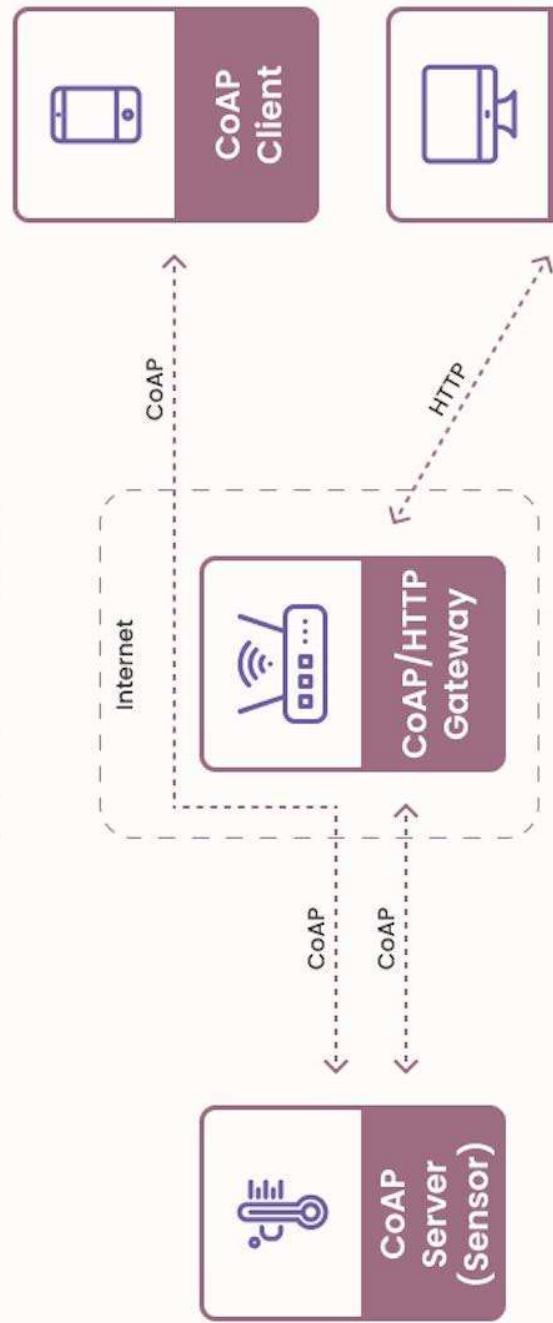
Smart Farming

Wearables

80

CoAP Protocol

Intuz



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Benefits and Drawbacks of CoAP

Intuz

Benefits

- Reduced Power Requirements
- Grass-Root-Level Usage
- Security
- Prompt

Drawbacks

- Unreliability
- Longer Processing Times
- Lousy Implementation Methods

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Aspect	MQTT	CoAP
Protocol Type	Publish/subscribe messaging protocol	Request/response messaging protocol
Application	Widely used in IoT and M2M applications	Primarily used in constrained IoT environments
Communication	Asynchronous	Synchronous
Payload	Supports lightweight binary and text-based payloads	Supports binary and text-based payloads
QoS	Supports three levels of Quality of Service (QoS): 0, 1, and 2	Supports four levels of reliability: 0, 1, 2, 3
Reliability	Provides reliable message delivery	Offers various reliability options based on message type
Header Size	Larger header size due to protocol overhead	Smaller header size, suitable for constrained environments
Transport Layer	Typically used over TCP/IP or WebSocket	Typically used over UDP or SMS transport protocols
Security	Supports TLS encryption for secure communication	Supports DTLS for secure communication
Usage	Suitable for applications requiring reliable messaging and low overhead	Ideal for resource-constrained devices and low-power networks
Discovery	Requires additional mechanisms for service discovery	Built-in support for resource discovery through CoRE Link Format

INNOVATION

Environment, Social, Governance

How IoT Can Improve ESG—For Companies And Communities



Brady Brim-DeForest
Forbes Councils Member
Forbes Technology Council COUNCIL POST | Membership (Fee-Based)

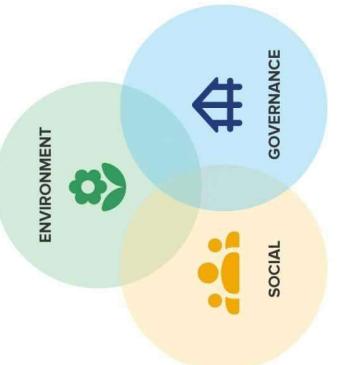
Nov 18, 2022, 08:30am EST

環境保護Environmental、社會責任Social、公司治理Governance

<https://www.forbes.com/sites/forbestechcouncil/2022/11/18/how-iot-can-improve-esg-for-companies-and-communities/?sh=176d70d1fa26>

- Improved Energy Efficiency Means Savings—In Costs And To The Environment
- IoT Monitoring Can Improve Health And Security
- Large-Scale Changes Benefit Companies And Their Constituent Communities

ESG Framework



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物聯網技術提升工地管理 實踐ESG



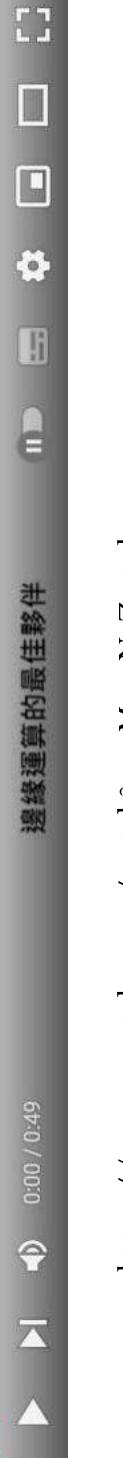
工程事業群 中鼎
倉研中心 助理總工程師 張泰源



資訊科技的導入，是CTCI中鼎集團發展iEPC智能化包工程的關鍵，而物聯網（Internet of Things，以下簡稱IoT）環境的建構則是第一步。IoT的建構，係將各種內建感測器的「物體」，藉由無線或有線的方式串連起來，並透過網路來監控、處理並分析資訊，以推升工作效率。近年來，在AI、大數據、區塊鏈、5G、邊緣運算及雲端運算等新科技的發展與結合下，更進一步形成了新世代人工智慧物聯網（Artificial Intelligence of Things, AIoT）的概念，因此，IoT結合AI形成AIoT，對企業而言無疑是蒐集經營過程中所產出重要資訊的基礎應用載具，亦是協助企業永續發展的關鍵技術，透過AI機制協助，輔以經驗豐富的領導層做出最佳判斷形成決策，進而推動ESG（環境、社會、公司治理）三面向的進步，進而打造出安全舒適的職場生活環境。本文將分享CTCI創研中心如何透過AIoT技術，逐步實現工地的智慧化管理，實踐ESG。

實戰範例：辦公室燈光節能省電 ESG 佔位偵測器 [THC-1103-OCU]

- ◆ 佔位偵測 連動燈光明暗度
- ◆ 滿足辦公室節能省電ESG



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<https://www.youtube.com/watch?v=-MqmNcZmtuk>

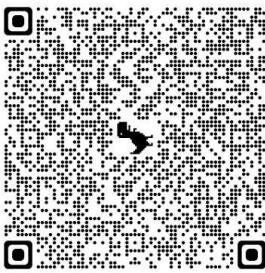
什麼是行動物聯網？
中華優勢
應用情境
物聯網連線管理平台
彈性費率
我有興趣
Q/A 常見問題



中華電信 行動物聯網

用科技智慧提升管理效率、
創造產業新契機！

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應用層

智慧應用

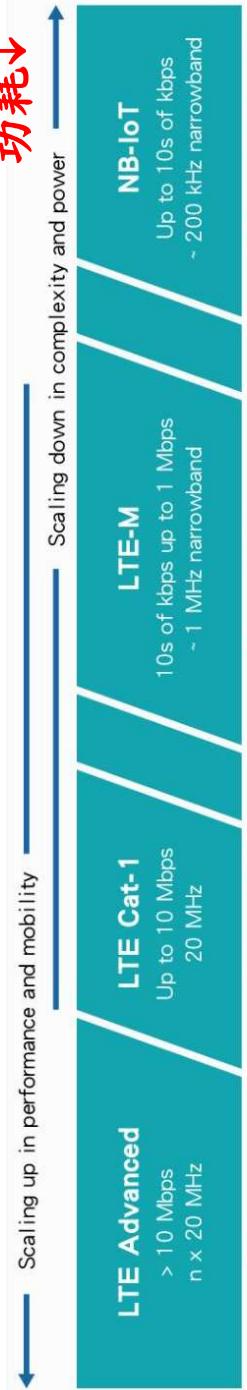


感知層

提供各式物聯網終端設備，一般/工業級三合一式插拔式SIM卡、以及具eSIM功能之CHIP SIM可供使用

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↑移動性



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VERY IMPORTANT

智慧農業物聯網

即時掌控農作物生長藍圖，
打造屬於作物的舒適圈

透過行動物聯網（NB-IoT/LTE-M）
及環境感知器，實現更智慧的精準耕種。

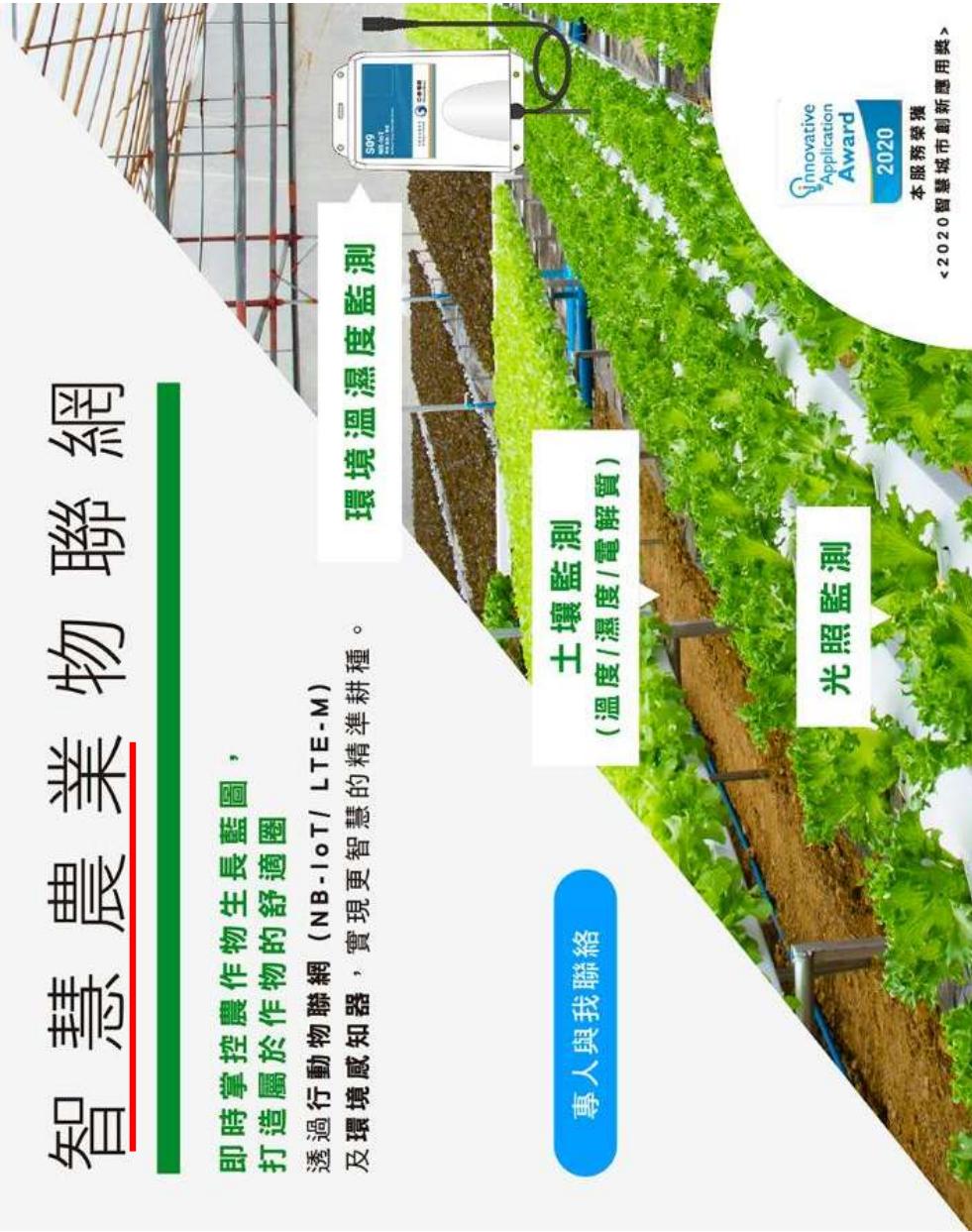
環境溫濕度監測

專人與我聯絡

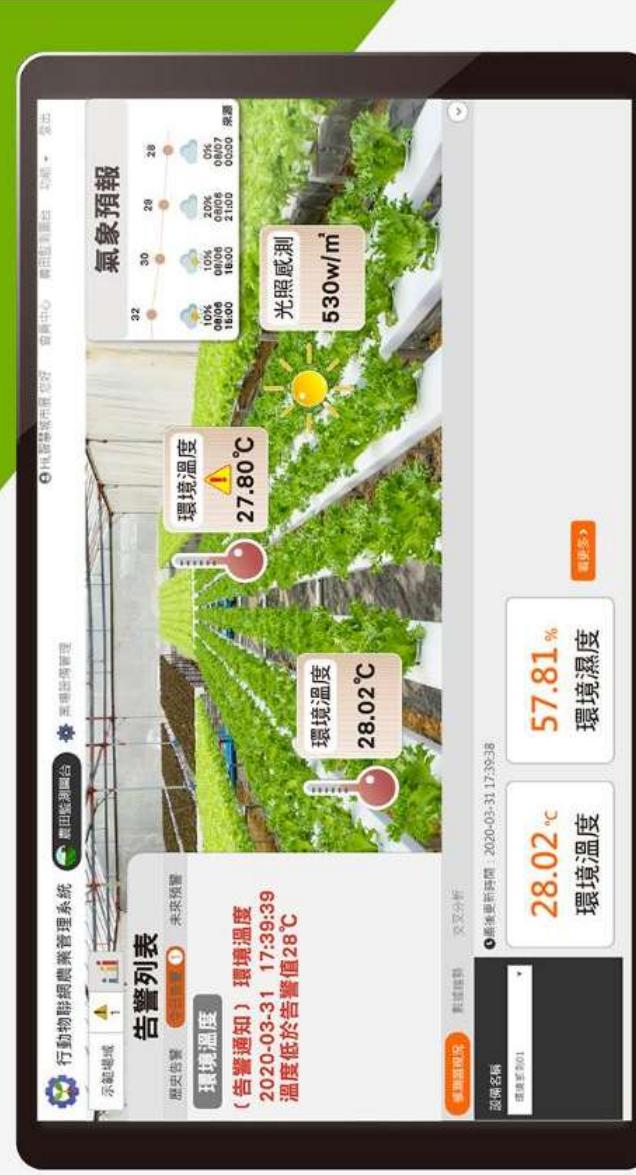
土壤監測
(溫度/濕度/電解質)

光照監測

91



智慧監測畫面示意



有哪些好處？

- 即時掌控農作物生長藍圖，打造屬於作物的舒適圈。
- 透過智慧農業物聯網蒐集數據，適時調整作物生長環境設定，高效率提升產能。
- 透過智慧農業物聯網降低工作量，滿足作物最適的生長要求，打造精準的耕種環境。

92

智慧停車物聯網

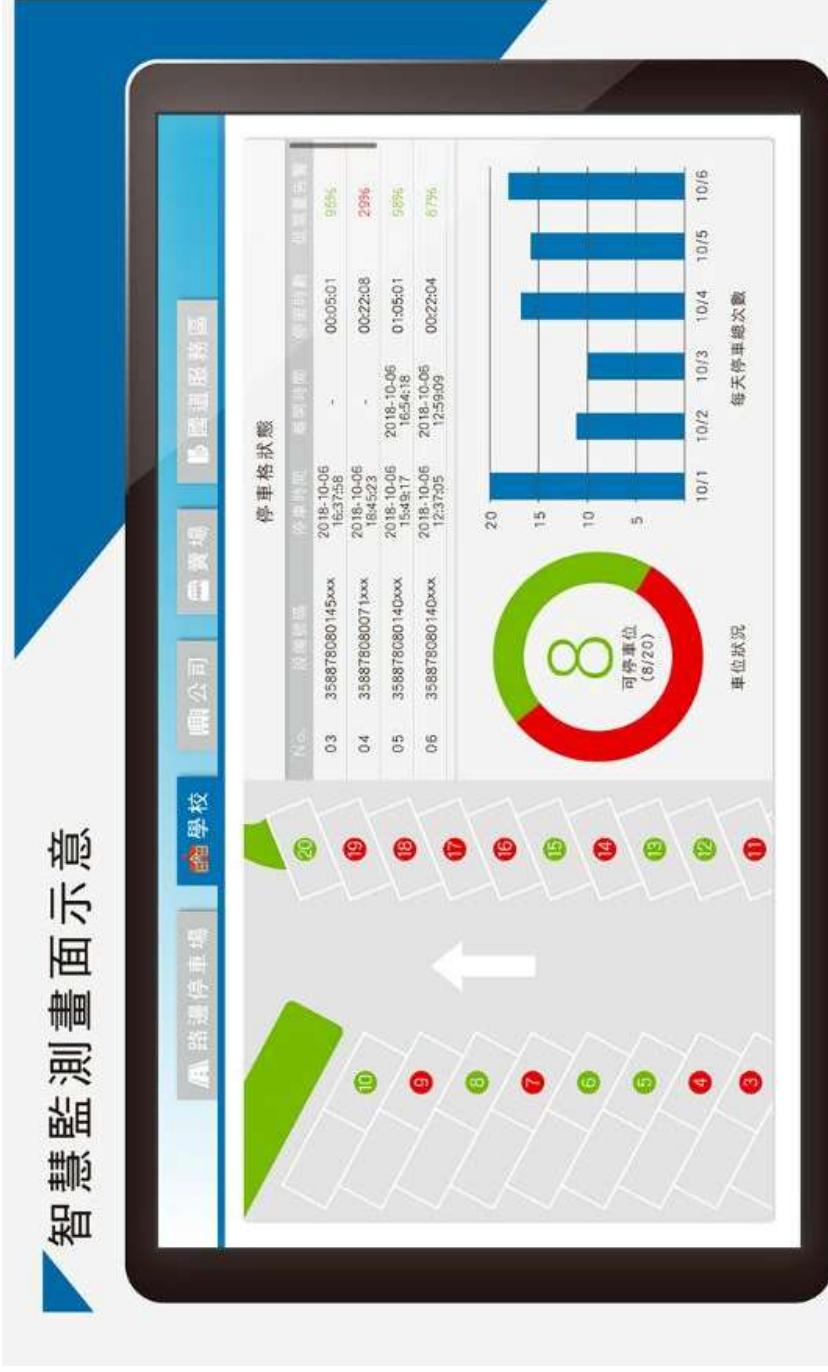
智慧城市，從優化停車管理開始！

透過行動物聯網(NB-IoT/LTE-M)及地磁感測器，
精準掌握路邊停車格的使用狀況，
建立更智慧的停車管理機制。



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智慧監測畫面示意



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智慧監測物聯網 M-IoT Gateway

串聯設備、環境、廠房等多方資訊
快速整合監測數據，提升管理效率
M-IoT Gateway串連物聯設備與雲平臺，
提供遠端監控應用。

M-IoT Gateway

專人與我聯絡

智慧監測畫面示意



有那些好處？

- 加速工業監控服務上線:不需佈線及自建平台，達到快速整合效果。
- 一條龍的服務:透過行動物聯網，將PLC控制設備資訊，整合至中華電信IoT雲端平臺。
- 感測數據化:數據監控集中化，提升溝通效率，降低出差成本。

智慧監測物聯網

食品業、醫療業、物流業、倉儲業
都不可或缺的智慧幫手！

透過行動物聯網(NB-IoT/LTE-M)及溫濕度感測器，
對運輸或儲藏中的商品進行智慧環境監測，
確實掌握商品儲存品質。



智慧監測畫面示意



有哪些好處？

- 自動化溫濕度管理、即時掌握貨品儲存環境。
- 數位化的紀錄服務可供歷史數據分析，節省人力成本，優化營運效率。
- 自動偵測觸發警報，確保貨品的安全及品質、降低貨損機率。

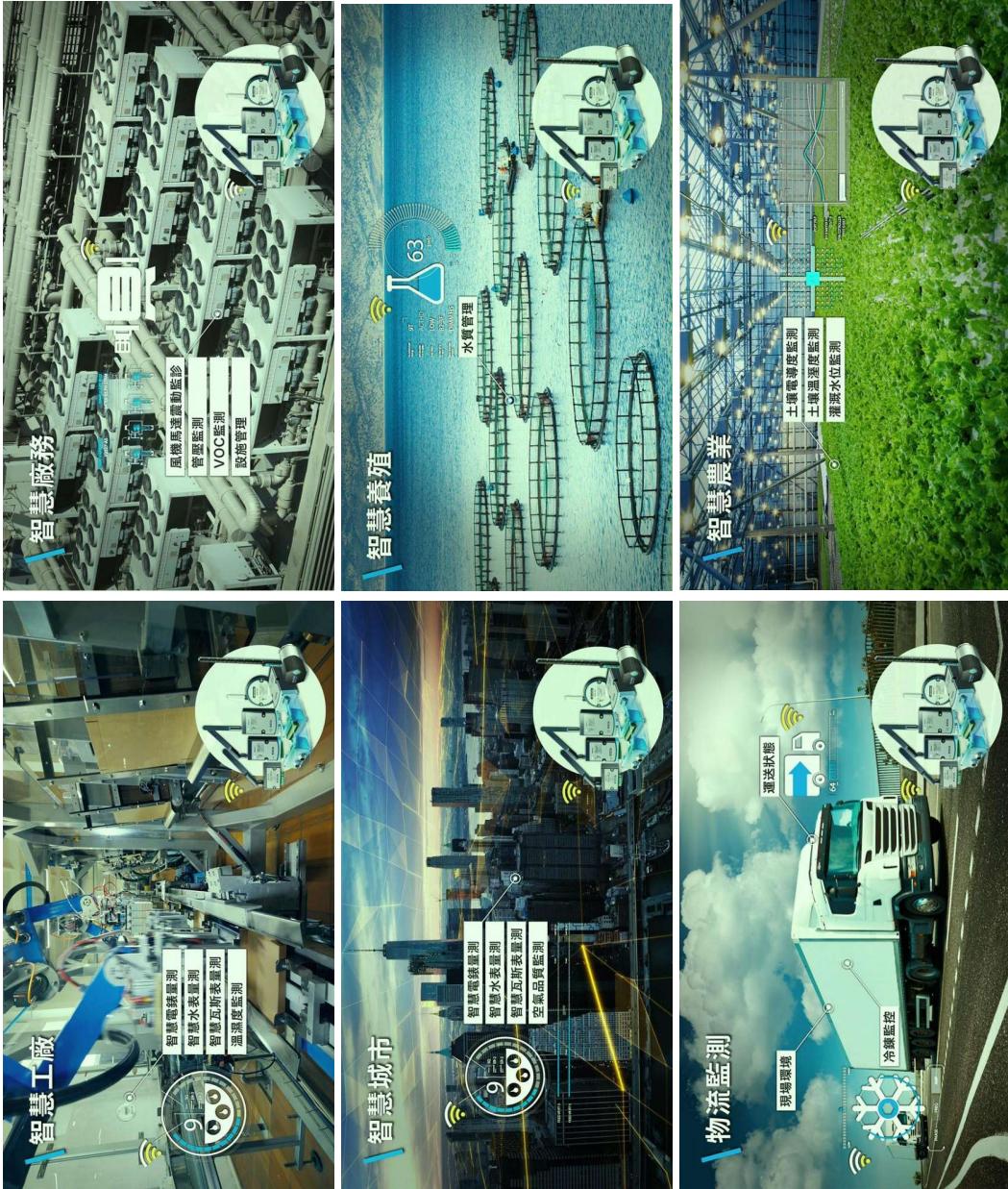
節能減碳人人有責
看看各場域可以怎麼做

ADVANTECH IoTMart



https://iotmart.advantech.com.tw/Widget.aspx?WidgetID=3051&gclid=Cj0KCQjw6pOTBhCTARIxAHF23flpDDjcBjFZK3lqYhfs4vSvh_NMk-y_GVELZT0tdA6br-VseH2QSUaAk6oEALw_wcB

99



100

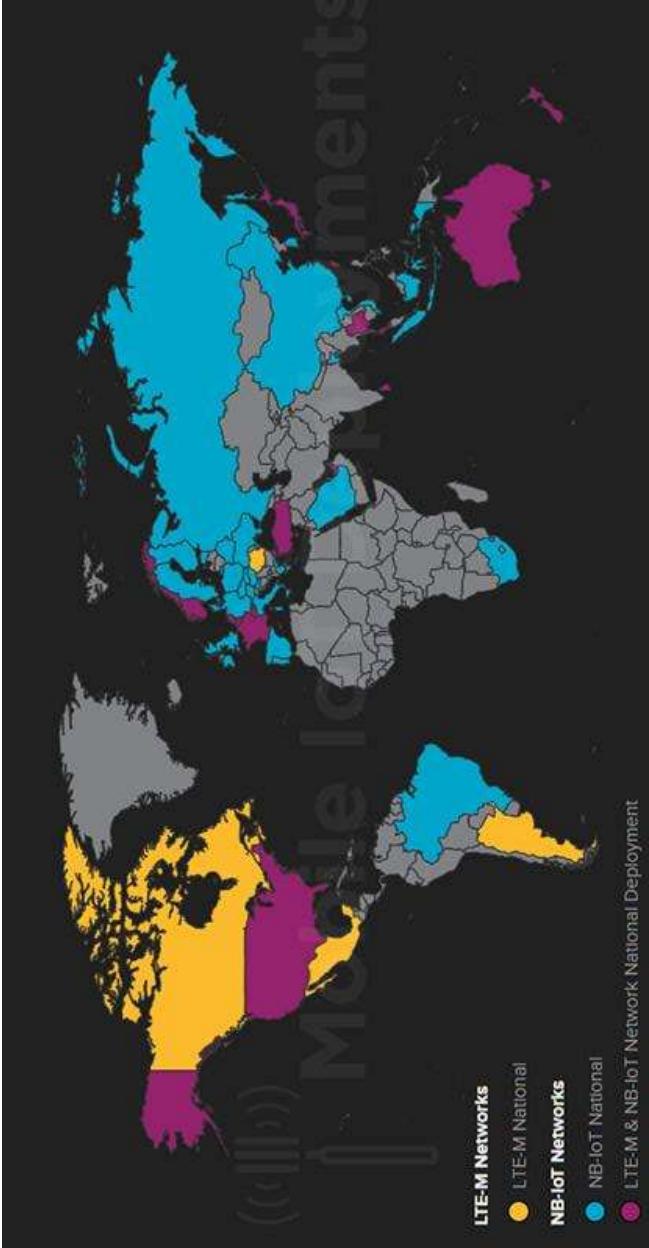


101

YouTube

<https://www.youtube.com/watch?v=pf7wc11IZYc>

NB-IoT全球部署狀態 (2019)



全球有超過50個國家佈署，超過100個電信營運商參與

<https://www.2cm.com.tw/2cm/zh-tw/tech/30D3FD9B745C4300AA2723720428DDDE8>

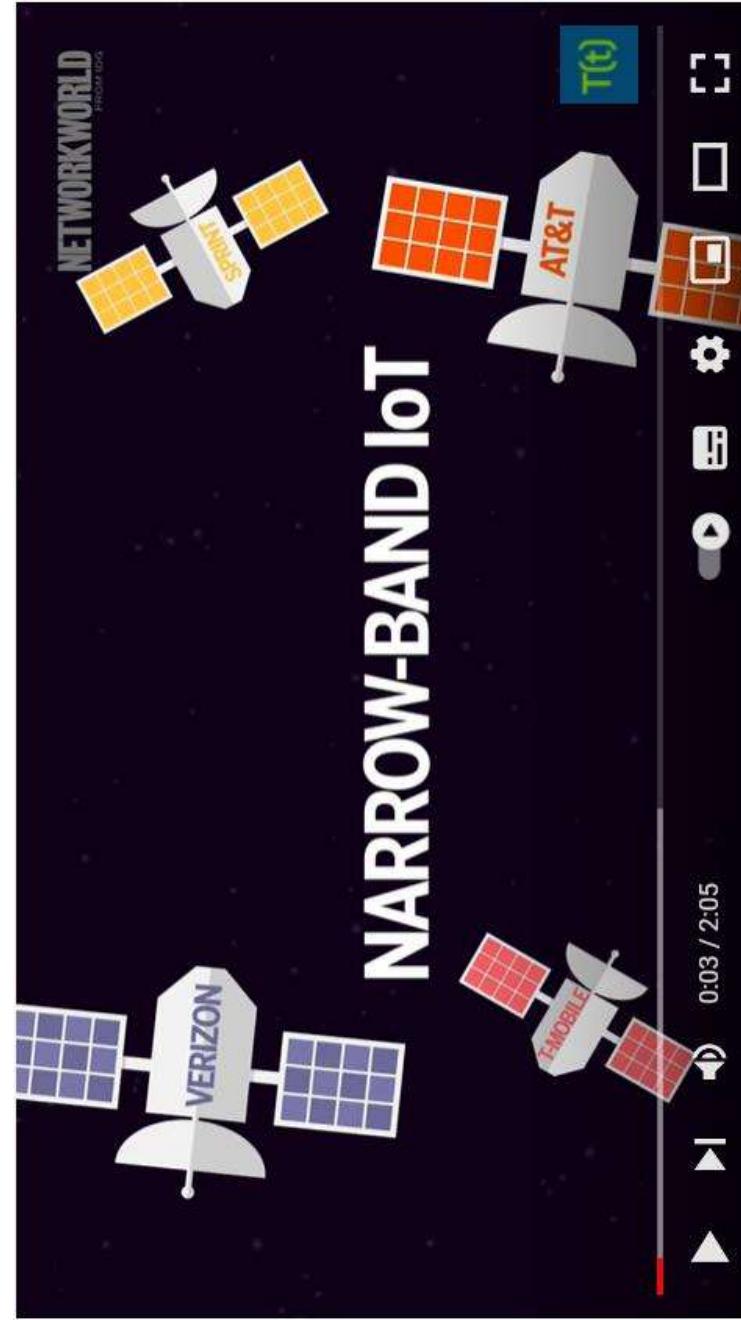
102

後發先至、潛力無窮

知己知彼、創造機會

	NB-IoT	LTE-M	Sigfox	LoRa
Frequency Band	Licensed Spectrum Feature(700MHz~2.5GHz)	In-Band LTE	Unlicensed 920.8MHz	Unlicensed 920~928MHz
Bandwidth	200KHz	1.4MHz	100Hz	125kHz
Deployment	In-band、Guard band、Standalone	In-band	Standalone	Standalone
Modulation Scheme	DL : OFDMA UL : SC-FDMA	DL:OFDMA UL:SC-FDMA	UNB(Ultra Narrow Band)	CSS(Chirp spread Spectrum)
Modulation	DL : QPSK UL : pi/4-QPSK、pi/2-BPSK、QPSK	DL : QPSK,16QAM UL : pi/4-QPSK、pi/2-BPSK、QPSK	NO{BPSK}	VSF{SF7~SF12}
Max. Data Rate (bps)	~21.25kbps DL ~62.5kbps UL	Full duplex1Mbps	100bps	30bps~50Kbps
UE	-142	-142	-142	-142
Sensitivity(dBm)	Half Duplex-FDD	Half Duplex-FDD/TDD	Half Duplex	Half Duplex
Communication channel	Limited to idle mode	Support Handover	70Km以内	70Km以内
Mobility				

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<https://www.youtube.com/watch?v=pf7wc1lZYc>

YouTube

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<https://www.youtube.com/watch?v=gCcQOeffD3Ew&t=4s>

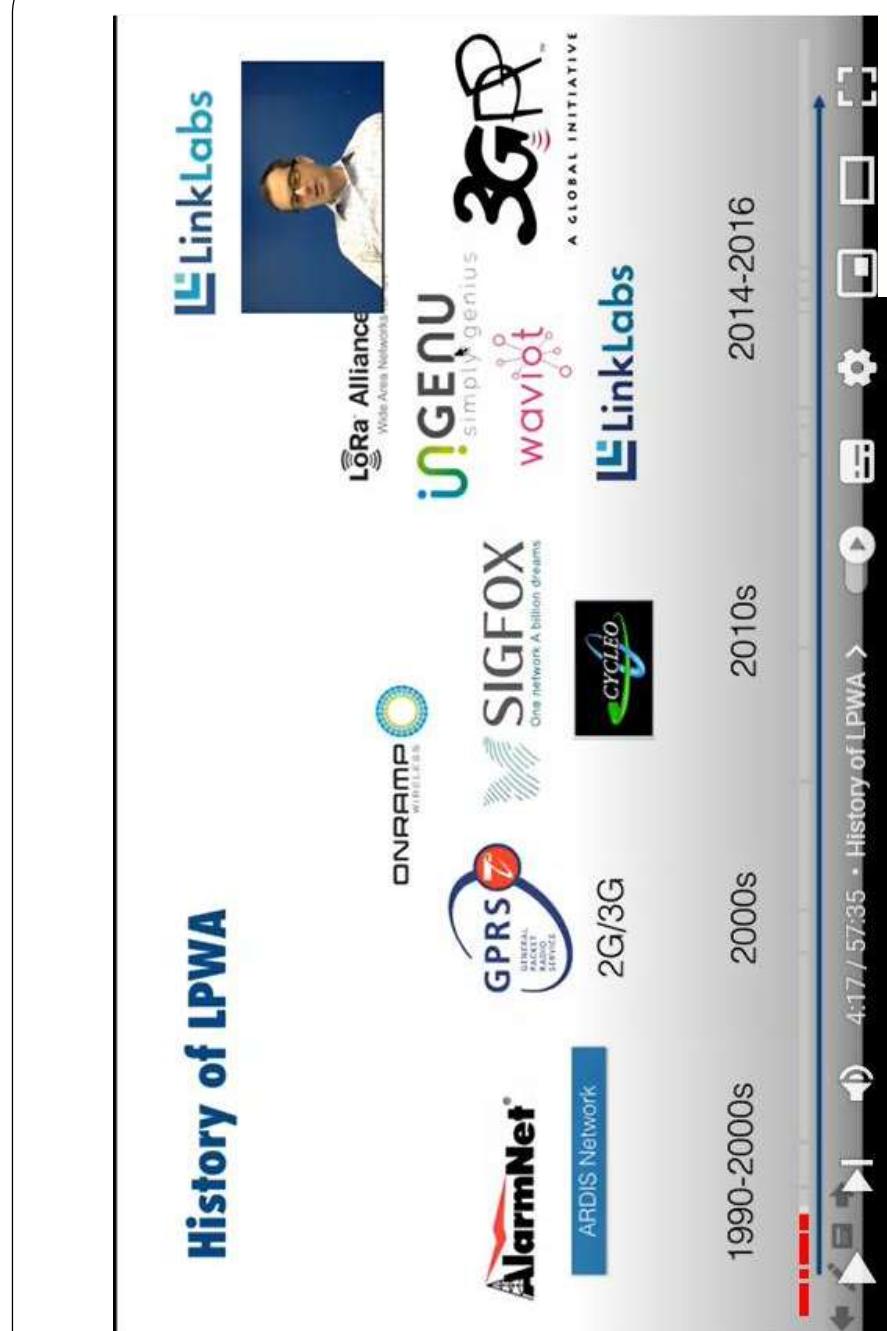


<https://www.youtube.com/watch?v=sjFzmL-z8HE>

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技術名稱 規格特性	LTE Cat.1	NB-IoT (亦稱為Cat-NB1)	eMTC (Cat.M1)
制定單位與版本	3GPP/Release 8	3GPP/Release 13	3GPP/Release 13
使用頻寬	20MHz	180kHz	1.4MHz
傳輸速率	上行速率：約5Mbps 下行速率：約10Mbps	上行速率：約66kbps (Release 13) 下行速率：約26kbps (Release 13)	上行速率：約1Mbps 下行速率：約1Mbps
延遲時間	100ms	1~16秒	10~15ms
傳輸距離	可達公里級	35公里	35公里
技術特性	<ul style="list-style-type: none"> 功耗較高 現有LTE基地台經軟體升級即可支援。 全雙工(可同時進行發送與接收) 可稱為LTE簡化版本 具行動性，支援100km/hr以上的移動速度。 	<ul style="list-style-type: none"> 低功耗，採用長時間休眠功能(PSM、eDRX)技術，裝置最長可達3小時休眠時間。 半雙工(無法同時進行發送與接收) 現有LTE基地台經軟體升級即可支援，亦可獨立部署。 因使用頻寬很窄，因此可用LTE技術不敢使用的頻段，亦即可再利用LTE技術省費的頻段。 	<ul style="list-style-type: none"> 功耗中等，採用eDRX技術，裝置可長時間休眠。 現有LTE基地台經軟體升級即可支援。 行動性
鎖定應用	物聯網相關應用，例如車載資訊系統、資產追蹤、安全監控與報訊等。	<ul style="list-style-type: none"> 目前在中國市場爆紅 	<p>不要求即時性、可以低速率傳輸的物聯網應用，例如水表、電表。</p> <ul style="list-style-type: none"> Release 14版本提升了傳輸速率，上行速率約為159kbps，下行速率約為127kbps。 Release 14版本技術名稱為Cat-NB1。
備註	<p>https://www.eettaiwan.com/20210415nt31-nb-iot-cat-1-etmc-market-trend/</p>		

History of LPWA



- eMTC: enhanced Machine-Type Communication 增強型機器類型通信
- LTE-M: LTE Machine-to-Machine
- Cat: Category

LTE-M與NB-IoT規格比較

	LTE-M	NB-IoT
別稱	eMTC、LTE Cat-M1	LTE Cat-NB 1
頻寬	1.08MHz	180kHz
傳輸峰值	1Mbps	30/60kbps
傳輸範圍	155.7dB	164dB
延遲性	1.5~10秒	50~100毫秒
傳輸支援類型	數據、語音	數據
移動性	可支援移動設備	僅支援靜態設備
網路部署	易於透過現行LTE網路升級	GSM網路更易合併
FOTA	支援	支援
使用年限	5~10年	10年以上

- 延遲性(Latency): 進入網路並發送消息所需時間
- 批次傳送 vs 即時通訊

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	LTE-M	NB-IoT	說明
傳輸速率	👉		單位時間內可傳送更多的數據
頻寬	👉		有較大的數據吞吐量
語音傳輸	👉		由每個營運商決定是否在其網路上實施
穿牆能力	👉		設備布置選擇更有彈性
移動性	👉		具備不同基站的切換能力，可應用在車聯網
營運商佈署	?	?	各國現行電信基礎架構是考量因素之一

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LTE-M

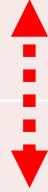
NB-IoT

LTE

AT&T(美國)、Verizon(美國)
Vodafone(英國@紐西蘭、荷蘭)、
Orange(法國@法國、羅馬尼亞)、
Bell(加拿大)、Spark(紐西蘭)

GSM

中國移動、中國聯通、中國電信、
台灣大哥大、遠傳、KT(韓國)、
T-Mobile(美國)、Telia(瑞典)、
Vodafone(英國@德國、希臘)



中華電信、亞太之星、軟銀(日本)、Telstra(澳洲)、
Orange(法國@比利時)

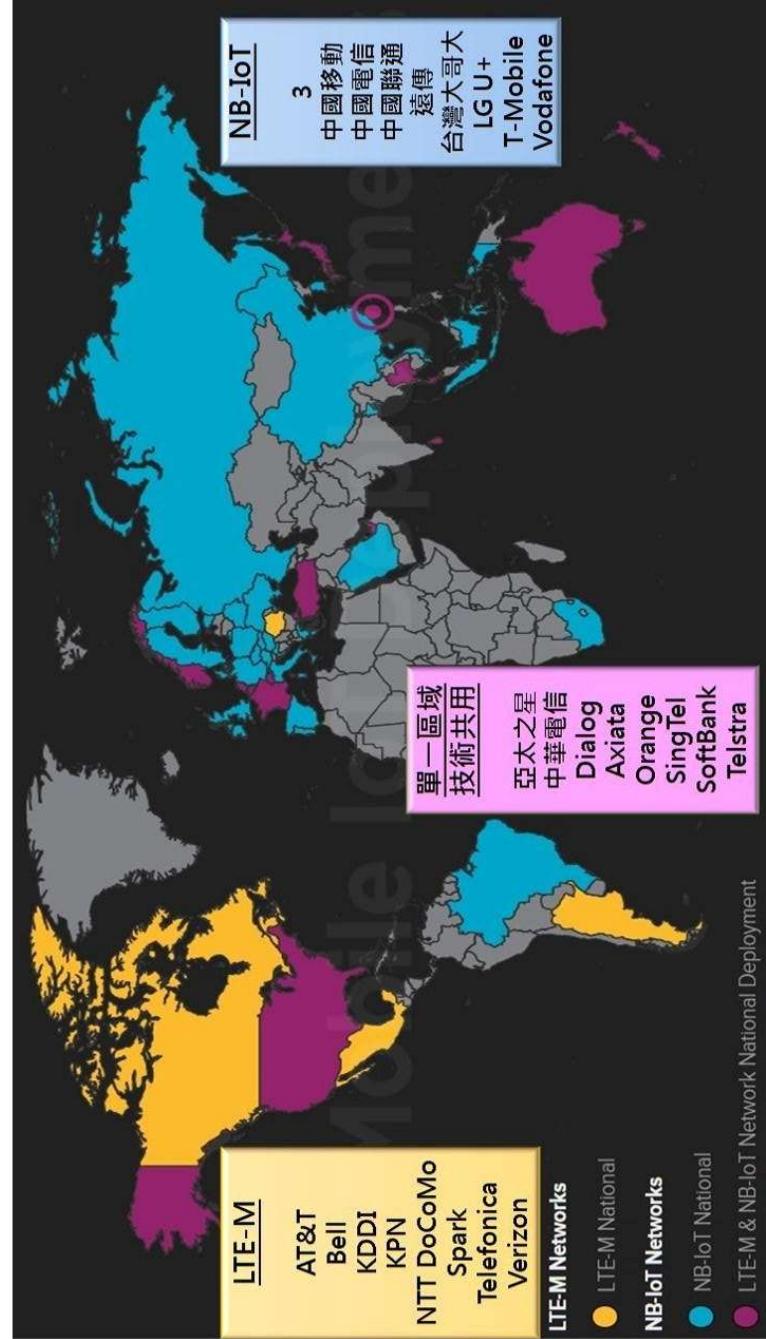
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通訊技術	英文全稱	說明
LTE (3.9G)	Long Term Evolution	商業上指稱的 LTE 其實是俗稱的 3.9G，亦為 4G 的過渡版，正式的 4G 應為 LTE A，但礙於習慣大家仍會將 4G LTE 混稱在一起。LTE 是給予擁有 GSM/UMTS 網路的最平滑的升級路線，有能力提供 299.6 Mbit/s 的下載速率和 75 Mbit/s 的上傳速率，簡化和重新設計網路體系結構，使其成為 IP 化網路，這有助於減少 3G 轉換中的混音。因為 LTE 的介面與 2G 和 3G 網路互不兼容，所以 LTE 需同原有網路分頻段。
HSUPA (3.75G)	High Speed Uplink Packet Access	因 HSDPA 上傳速度不足而開發，上傳資料的速度可以達 5.76 Mbps，可應付於直撥或 VoIP 的使用。
HSDPA (3.5G)	High-Speed Downlink Packet Access	高速下行封包存取是一種基於 WCDMA 基礎的行動電話技術，可讓 UMTS 基級，以達到更高的資料專輸速度。初期 HSDPA 支援 1.8 Mbit/s 或 3.6 Mbit/s 速度，現已達到 14.4 Mbit/s。
WCDMA (3G)	Wideband Code Division Multiple Access	第三代無線通訊技術，以 GSM 作為發展網路的基礎，因此 GSM 業者最適合選擇系統過渡至 3G，目前廣泛所指稱的 3G 上網就是 WCDMA。
GSM (2G)	Global System for Mobile Communications	目前應用最為廣泛的行動電話標準，其訊號和語音通道都是數位式的，因此 GSM 是第二代行動電話系統，GSM 標準目前由 3GPP 組織負責制訂和維護。
CDMA (2G)	Code Division Multiple Access	與 GSM 同為第二代行動通訊技術相同時期發跡，亞太電信引進美國地區所採用的 C

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全球LTE-M與NB-IoT主要營運商與國家分布



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IoT ANALYTICS

Your Global IoT Market Research Partner

March 2022

Impact of 16 macro factors on IoT markets (2022–2027)

Economic		Political/Social		Environmental		Technological	
Factor	Expected Impact	Factor	Expected Impact	Factor	Expected Impact	Factor	Expected Impact
① Lower than anticipated demand growth	Red	⑤ Nearshoring/ Reshoring	Green	⑨ Sustainability goals	Green	⑫ Maturing artificial intelligence	Green
② Rising input prices	Red	⑥ Russian invasion of Ukraine	Red	⑩ Reducing fossil fuels	Green	⑬ Cloud vendors focus on IoT	Green
③ Lower valuations for disruptive technologies	Grey	⑦ Skill/Labor shortage	Red	⑪ Living with COVID-19	Green	⑭ Maturing connectivity	Green
④ Unstable supply chains	Green	⑧ European Data Act	Grey	⑯ Increasing cybersecurity incidents	Red	⑮ Chip shortage	Red

Legend: ● Headwind ● Neutral ● Tailwind ●順風 ●逆風

Source: IoT Analytics Research 2022. We welcome republishing of images but ask for source citation with a link to the original post or company website.

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Technology comparison

M2M是共同的應用重點

Feature	2G (GSM / GPRS)	Cat M1 (half duplex) Mobile connectivity / M2M	Cat NB1 (NB-IoT) M2M	RPMa	LoRa	SigFox
Application focus	Mobile connectivity / M2M	1.4 MHz 3GPP Licensed ¹	180 kHz 3GPP Licensed ¹	M2M 80 MHz ISM Unlicensed ² Global 2.4 GHz Band	M2M 125 kHz (typ) ISM Unlicensed ² 868 MHz (EU) / 915 MHz (USA)	M2M 600 Hz ISM Unlicensed ² 915 MHz (USA)
Radio Spectrum	200 kHz 3GPP Licensed ¹					
Guaranteed Quality of Service (QoS)	Yes	Yes	Yes	No	No	No
Responsiveness	milliseconds => seconds	milliseconds => seconds	seconds => minutes	seconds	seconds => minutes	sec's => min's (140 Tx / day limit)
Roaming 漫遊	Global	Global	Global	Local ³	Single network	
Peak Data Rate	Up to 85.6 kbps (DL) Up to 42.8 kbps (UL)	375kb/s (DL/UL)	27.2 / 62.5 kb/s (DL/UL)	31 / 15.6 kb/s (DL/UL)	5.5kb/s (125bw) 50kb/s (500bw)	100kb/s (UL) 500kb/s (DL)
FOTA	No	Yes	Yes	Yes (broadcast channel)	No	No
Range / MCL ^e	Above ground / 139.4 / 144 dB Vehicular (300kmh) (full handover)	Basement / 155.7 dB Vehicular (300kmh) (no handover)	Underground / 164 dB Vehicular (100kmh) (full handover)	Underground / 167 dB Vehicular (100kmh) (no handover)	Underground / 161 dB Vehicular (100kmh)	Underground / 161 dB
Mobility	Yes (GSMA)	Yes (Incl. Vol. TEI)	No	No	No	No
Voice Support 語音						
Battery life 電池壽命	5-10yrs	5-10yrs ^a	10yrs ^b	10yrs ^c	10yrs ^d	\$
Cost (Module or End M)	\$	\$	\$	\$	\$	\$

Notes:

1. 3GPP Licensed spectrum in 450MHz and 700MHz = 3.5GHz.

2. ISM (Industrial, Scientific, Medical) unlicensed spectrum.

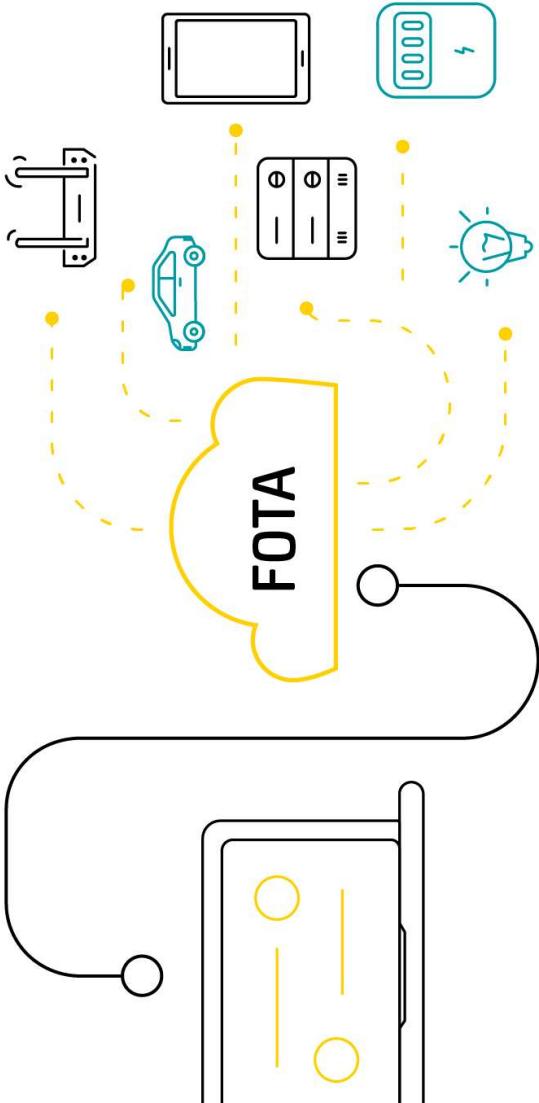
3. LoRa Public and Private networks are operated by entities in specific areas, there is no guarantee of cross-network operation.

FOTA (Firmware over the Air) 無線韌體升級

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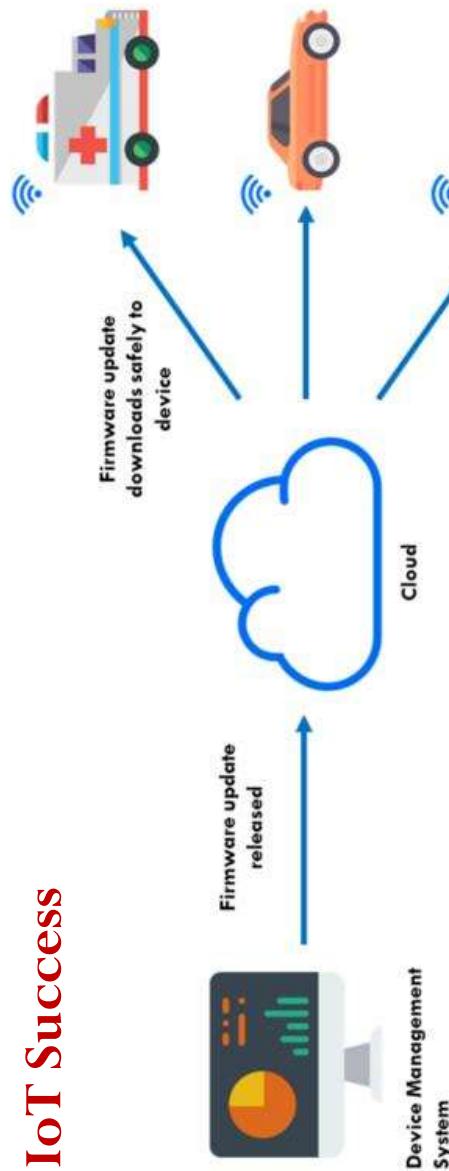
FOTA

- 行動裝置製造商和運營商可以將新韌體透過網路向裝置「推播」更新訊息，這降低了韌體更新的成本，提高了消費者的滿意度。



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Over-The-Air Firmware: The Critical Driver of IoT Success



- In 2015, Chrysler was criticized for patching a software vulnerability via **mailed USB drives**.
- In 2016, Tesla drivers woke up to find substantial new features to their car after the company sent out an **OTA firmware update**.

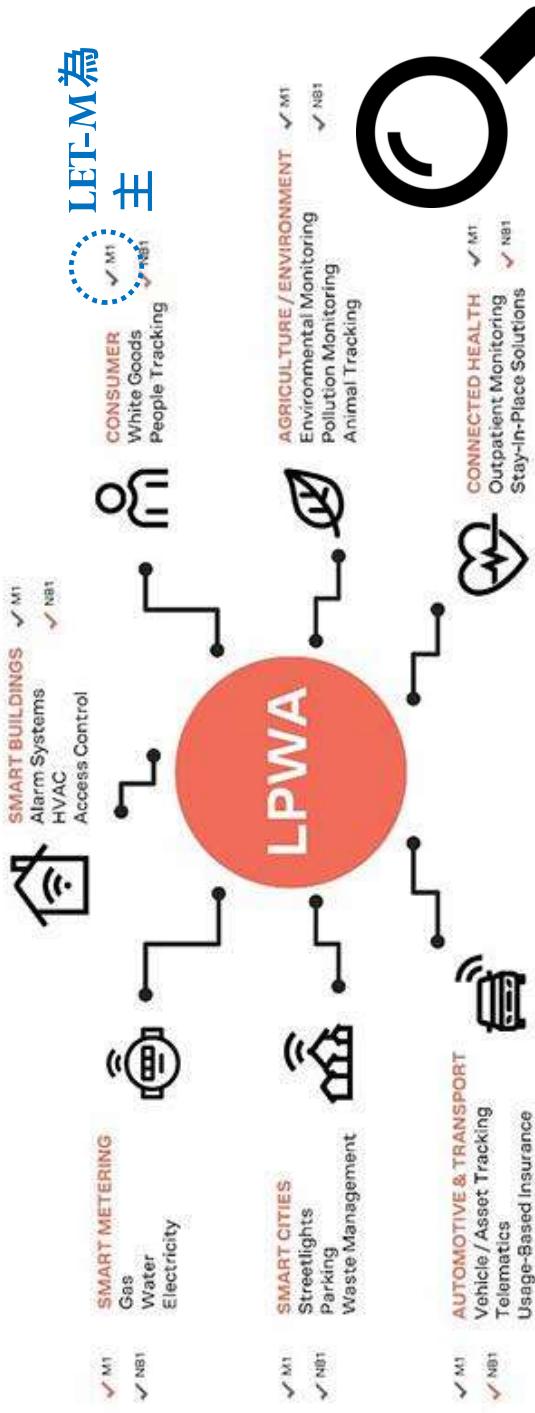
<https://clzone.com/articles/over-the-air-firmware-the-critical-driver-of-iot-success>

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Markets and applications

NB-IoT能深入地下室和提供10年以上的
電池壽命→智慧電表及超低功耗應用

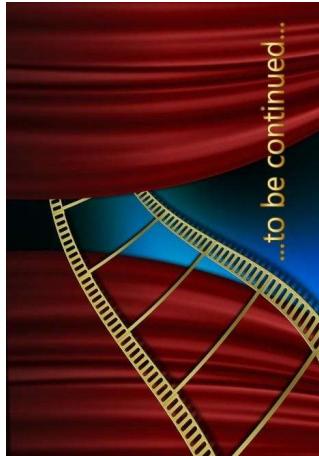


LTE-M可提供低延遲的行動連接，並能擴展覆蓋範圍到地下室、支援語音通訊，以及較高的數據傳輸率→智慧城市及消費性、聯網醫療、車輛和資產追蹤等

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- 在LPWA應用中，有兩種**應用層協定**正成為主流
 - 訊息佇列遙測傳輸(Message Queuing Telemetry Transport；**MQTT**)
 - 在**TCP/IP**協定上運作
 - 受限應用協定(Constrained Application Protocol；**CoAP**)
 - 在**UDP/IP**協定上運作
 - 應用層協定的選擇主要取決於傳輸層協定的選擇



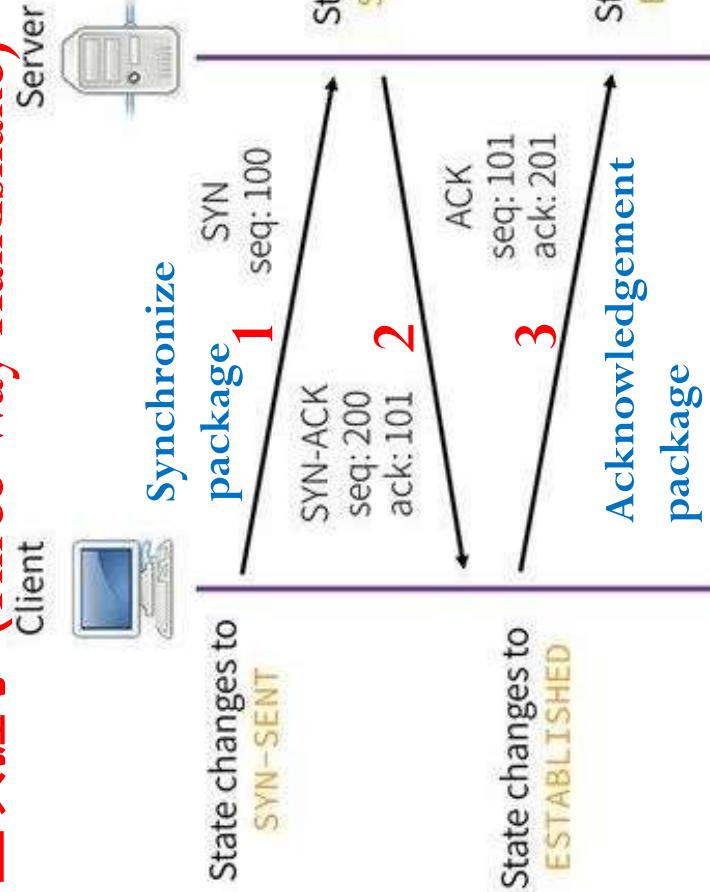
MQTT, CoAP, TCP, UDP

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- **TCP**
 - 可提供一定程度的控制，讓數據以**正確**的順序可靠地傳輸和重新組合，同時找出並修正錯誤，然後妥善地關閉連接；
 - 功耗較高。
- **UDP**
 - 數據封包僅簡單地發送到接收器，無須先建立連接，也不確保數據會被成功接收；
 - 無法保證所有的數據封包都被傳送、無法恢復丟失的封包，也無法偵測重複封包；
 - **降低功耗**。

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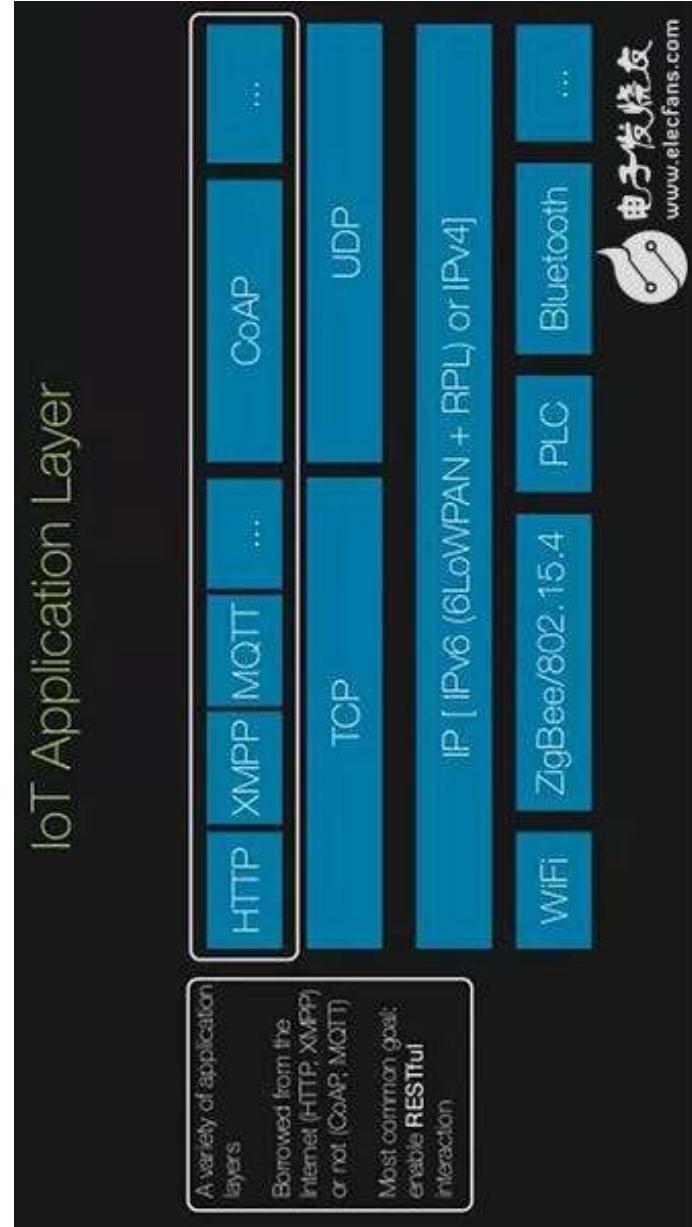
TCP三次握手 (Three-Way Handshake)



第一次握手：Client向Server發送封包，並發送隨機的序碼seq，
Server接收到封包，知道Client請求後建立連結；.....

<https://www.mdpi.com/2076-3417/6/11/358/htm>

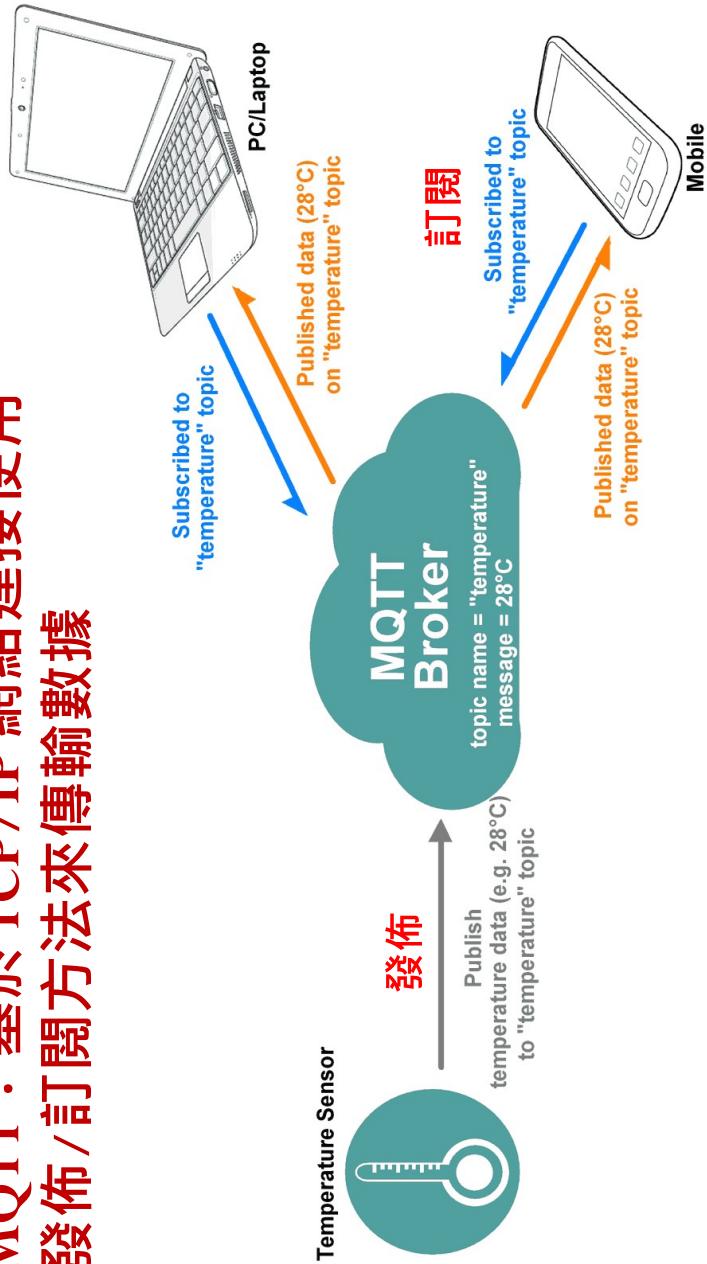
121



<https://www.ponews.net/tech/yuoel2zlk2o.html>

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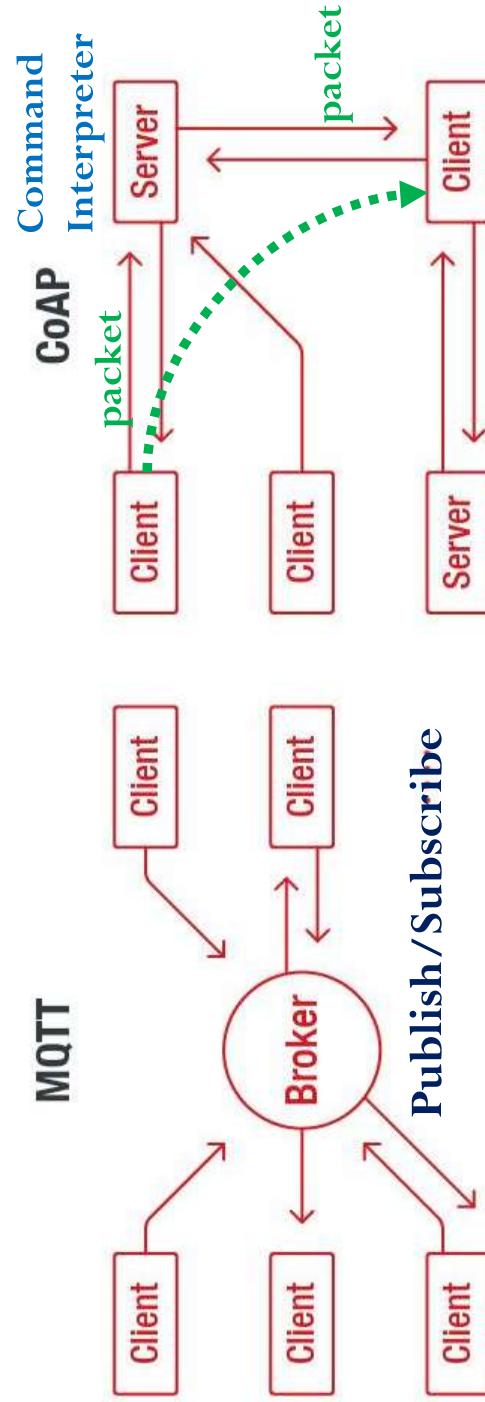
MQTT：基於TCP/IP 網絡連接使用 發佈 / 訂閱方法來傳輸數據



<https://www.itread01.com/content/1547174904.html>

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Machine-to-machine (M2M) communication protocols,
which enable machines to “talk” with one another



CoAP: The server does not necessarily
have to acknowledge the request.

<https://www.trendmicro.com/vinfo/tw/security/news/internet-of-things/mqtt-and-coap-security-and-privacy-issues-in-iot-and-iiot-communication-protocols>

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NB-IoT & LTE-M (Short Course ~46 min)

NB-IoT and LTE-M

NB-IoT and LTE-M – course content



- 1. Network architecture
- 2. Air interface – part I
- 3. Air interface – part II
- 4. MTC enhancements
- 5. MTC enhancements in EPC

YouTube

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<https://www.youtube.com/watch?v=nzUyPqh65M>

LTE-M 與 NB-IoT 特性比較

LTE-M (CAT M1) Vs. NB-IoT

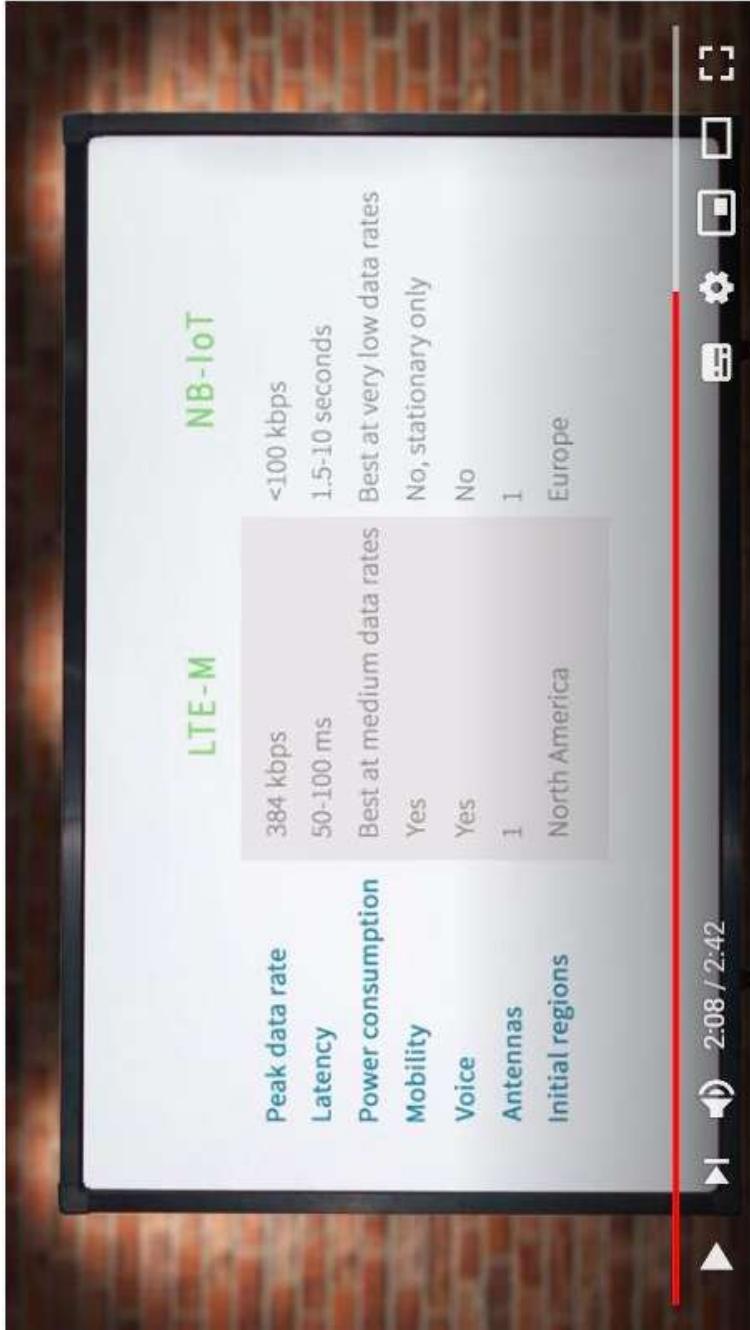
按 Esc 即可



<https://www.youtube.com/watch?v=sorVe6kb1uc>

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LET-M 與 NB-IoT 簡介



127

<https://www.youtube.com/watch?v=RjZ9rXbrJqM>



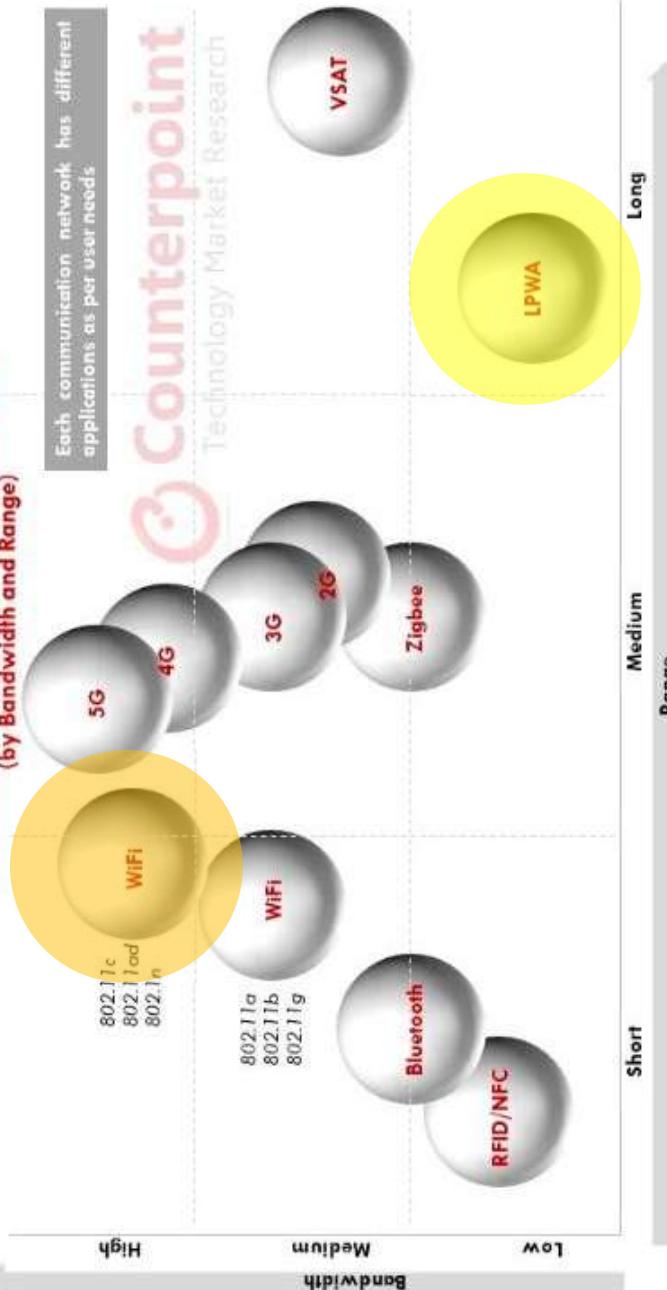
	2G/3G/4G	NB-IoT	sigfox	LoRa
特許頻率	✓	✓	✗	✗
國際標準	✓	✓	✗	✗
安全性	✓	✓	✗	▲
允許下行	✓	✓	▲	▲
傳輸速率	上行(Bit/s)	60M	250K	600
	下載(Bit/s)	226M	250K	100
訊號強度	標準144db	+20db	+16db	+13db
模組成本(NTD)	500~1600	<180	100~180	<180
電池運作時間(年)	2~3	10+	10+	10+

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<https://iot.taiwanmobile.com/iot/portal/solutionNB IoT>

頻寬

Different Network Communication Technologies
(by Bandwidth and Range)



129

<https://www.counterpointresearch.com/lpwans-will-co-exist-no-war-brewing-between-cellular-non-cellular/>

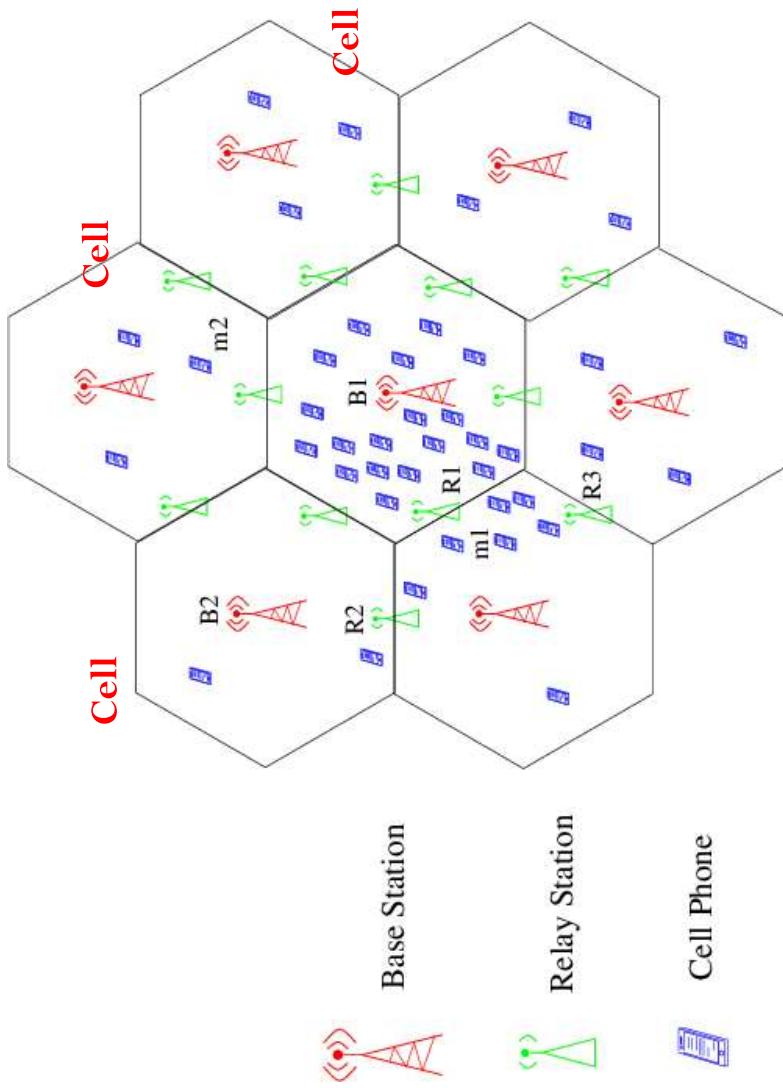
傳輸距離

蜂巢式網路

Parameters	EC-GSM	LTE-M	NB-IoT	Sigfox	LoRa
Spectrum	Cellular	Cellular	Cellular	Non-Cellular	Non-Cellular
Year of Origin	2017	2015	2016	2009	2015
Networks Announced	NA	26	68	48	74
Standardization	3GPP	3GPP	3GPP	Closed/Private	Open
Spectrum	Cellular	Cellular	Cellular	Non-Cellular	Non-Cellular
Channel Bandwidth	200 kHz	1.4MHz	180KHz	100 Hz	7.8-500 KHz
System Bandwidth	200 kHz	1.4MHz	180KHz	100 kHz	125 KHz
Peak Data Rate	DL 74 Kbps UL 74 Kbps	DL 800 Kbps UL 1 Mbps	DL 235 Kbps UL 205 Kbps	UL 100 bps DL 600 bps	180 bps~37.5 kbps

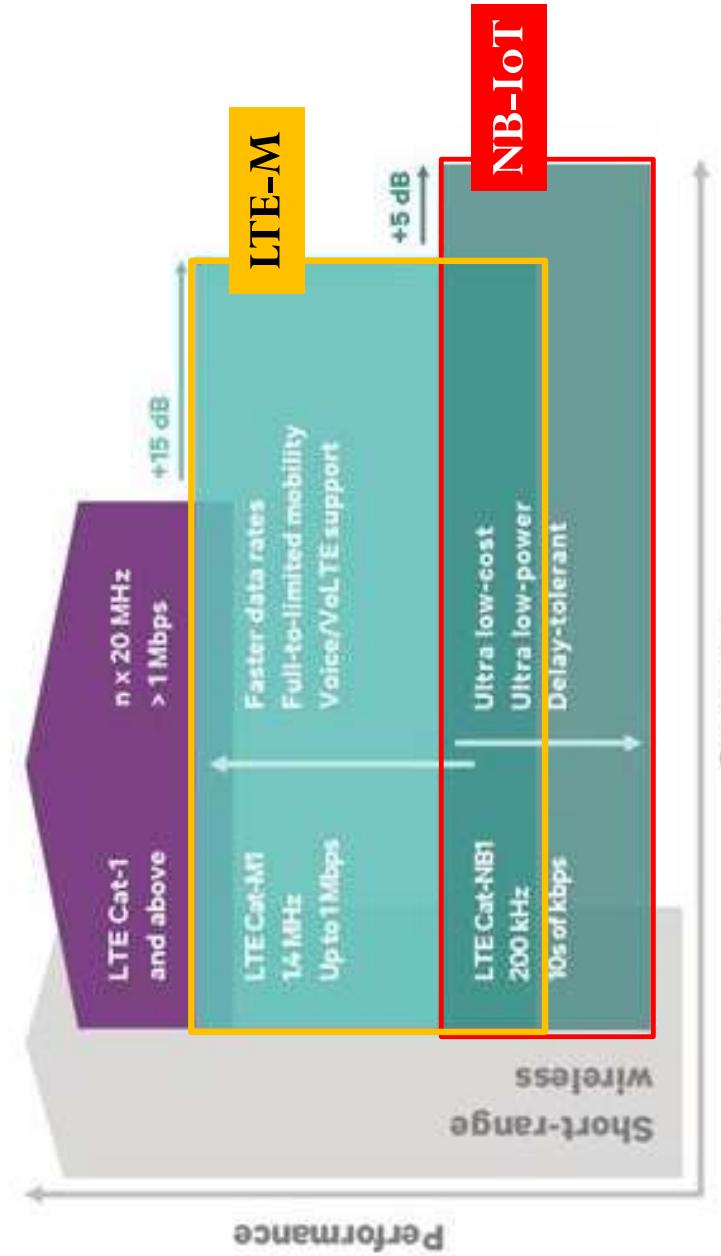
EC-GSM: Extend Coverage GSM

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蜂巢式網路架構示意圖



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Figure 4: LTE IoT - Cat-M1 and Cat-NB1 devices



Arduino SIM7000E NB-IoT/LTE/GPRS 4G 通訊擴展板 台灣各電信頻段 FDD-LTE B3/B8/B20/B28

★★★★★ (目前沒有評論)

NT\$1,960 NT\$1,790 (未稅)

Availability: 尚有庫存

貨號: IOT-003762

分類: 無線和物聯網

標籤: 4G, GLONASS, GNSS, GPRS, GPS, LTE, NB-IoT, NB-IoT, SIM7000, SIM7000E, TIS, 中華電網物聯網, 北斗衛星, 北斗衛星導航, 物聯網, 物聯網, 衛星定位



https://www.taiwansensor.com.tw/product/arduino-sim7000e-nb-iot-lte-gprs-4g-%E9%80%9A%E8%A8%8A%E6%93%95%94%95%9D%BF/?gclid=CjwKCAjwwYF2BRBGEiwAkobpAmfBer0c227GILrDBCnUPjhUOc8tEDkFd_QEf7HyrvTjTBZwtkrDhoCrEEQAvD_BwE

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Dragino NB-IoT Shield-B8 擴展板

目前沒有評論

NT\$1,905 NT\$1,505 (未稅)

Dragino NB-IoT Shield-B8 擴展板 是Arduino增加NB-IoT技術的擴展板。使用NB-IoT Shield和Arduino，用戶可以快速學習/評估並為NB-IoT解決方案進行POC

尚有庫存

<https://www.taiwaniot.com.tw/product/dragino-nb-iot-shield-b8-%e6%93%94%e5%9b1%95%e6%9d%bf/>

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作業

- 請觀看p.136影片。依據p.137說明，請回答以下問題：
 - 何謂AIoT？
 - AIoT應用在智慧工廠有哪些應用領域？
 - 在前述應用領域中，各自具體目標為何？
 - 主要的核心組件有哪些？
 - AIoT可提供那些解決方案用以提升智慧工廠的效能？

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https://www.youtube.com/watch?v=3IJUK_6wnLE

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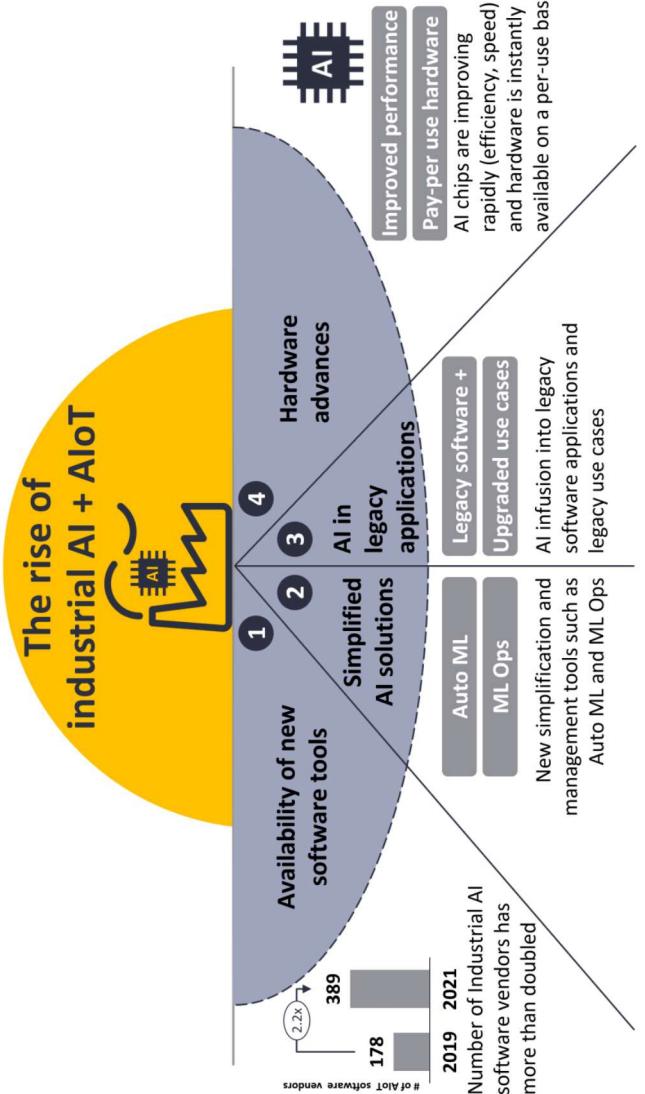
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Criteria	Zigbee	Z-Wave	WiFi	Bluetooth	Bluetooth Low Energy
Range	Good due to inherent mesh networking	Good due to inherent mesh networking	Good if repeaters or WiFi mesh used	Not great	Not great
Power Use (in theory)	Low	Low	High	Medium	Low
Bandwidth	Poor	Poor	Excellent	Poor	Poor
RF Band	2.4 GHz	908.42 MHz	2.4 GHz/5 GHz	2.4 GHz	2.4 GHz
Needs hub?	Yes	Yes	No (router)	No (smart phones)	No
# of smart devices available	Moderate	Not many (apart from sensors)	Lots	Barely any	Not many, but growing
Price of smart devices	High	High	Low	Medium	Medium
Part of Matter?	Yes	comparison No	Yes	Yes	Yes

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<https://www.smarthomepoint.com/zigbee-zwave-wifi-bluetooth/>

The rise of industrial AI + Alot



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<https://iot-analytics.com/rise-of-industrial-ai-alot-4-trends-driving-technology-adoption/>

3 generative Alot applications

1 Code generation for IoT

Large language models can be used to create, complete or combine IoT code, sourced from code snippets or natural language descriptions.

Example



GitHub Copilot

2 Robot control

Generative AI can be used to generate controls and commands of IoT connected robots by capturing motion data from animals or humans.

Example



Deepmind Robot Control Framework

3 Social IoT devices

Generative AI can be used to change the interaction with devices. Devices, for example, could provide the user with answers to complex questions.

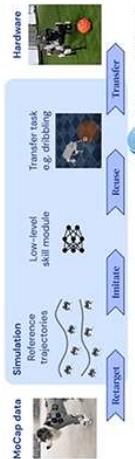
Example



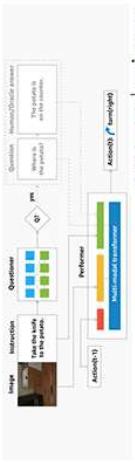
Amazon DialFRED



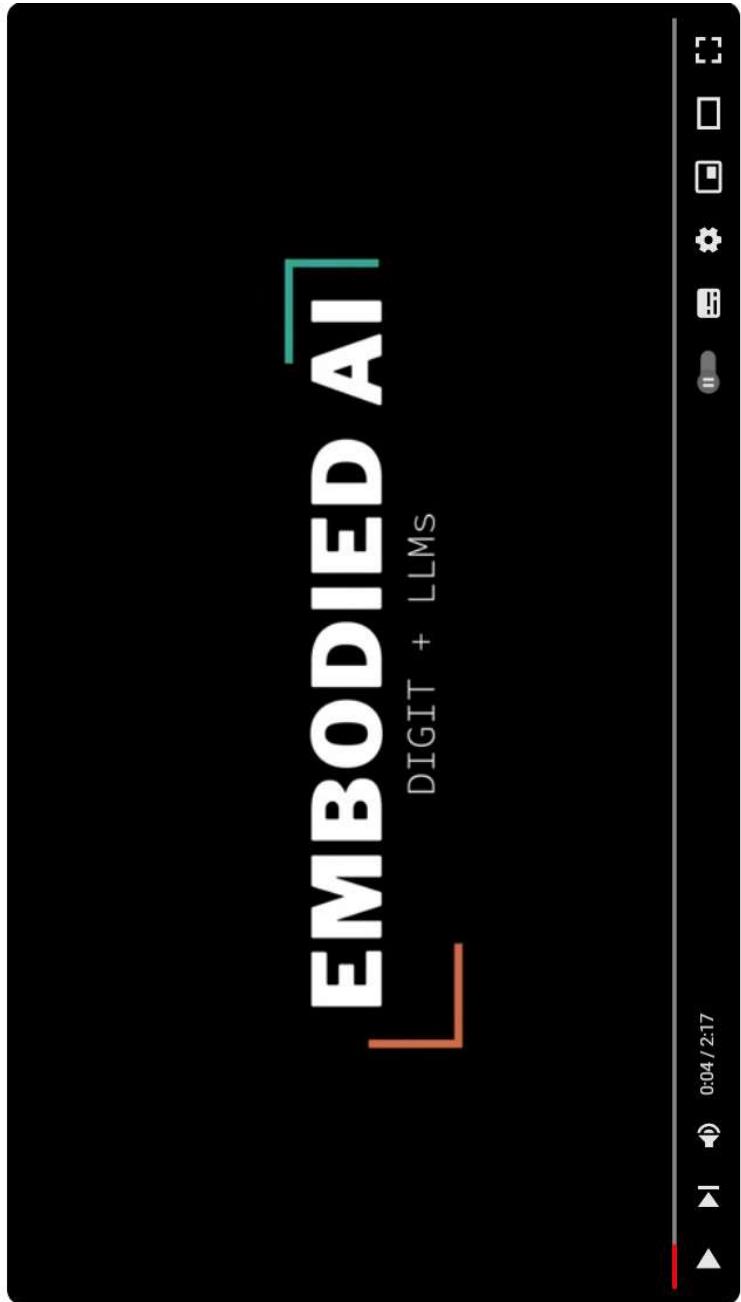
Source: IoT Analytics Research 2023. We welcome republishing but ask for source citation with a link to the original post and company website.



Source: DeepMind. GitHub Copilot



Source: Amazon. GitHub Copilot



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The 16 Top Cross-Industry IoT Analytics Applications



Wojciech Prażuch

Updated Feb 21, 2024 • 17 min read

<https://www.netguru.com/blog/iot-analytics-applications>

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- Intelligent retail solutions

- Queue detection
- Video analytics
- Just-walk-out shopping

- IoT analytics in agriculture

- Smart water management
- Forecasting fertilizer usage
- Cultivation recommendation systems

- Smart cities

- Traffic and energy management
- Energy management
- Smart solutions for public life

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- Data-driven healthcare

- Health condition monitoring
- Intelligent healthcare facilities management
- Smart data acquisition for medical research

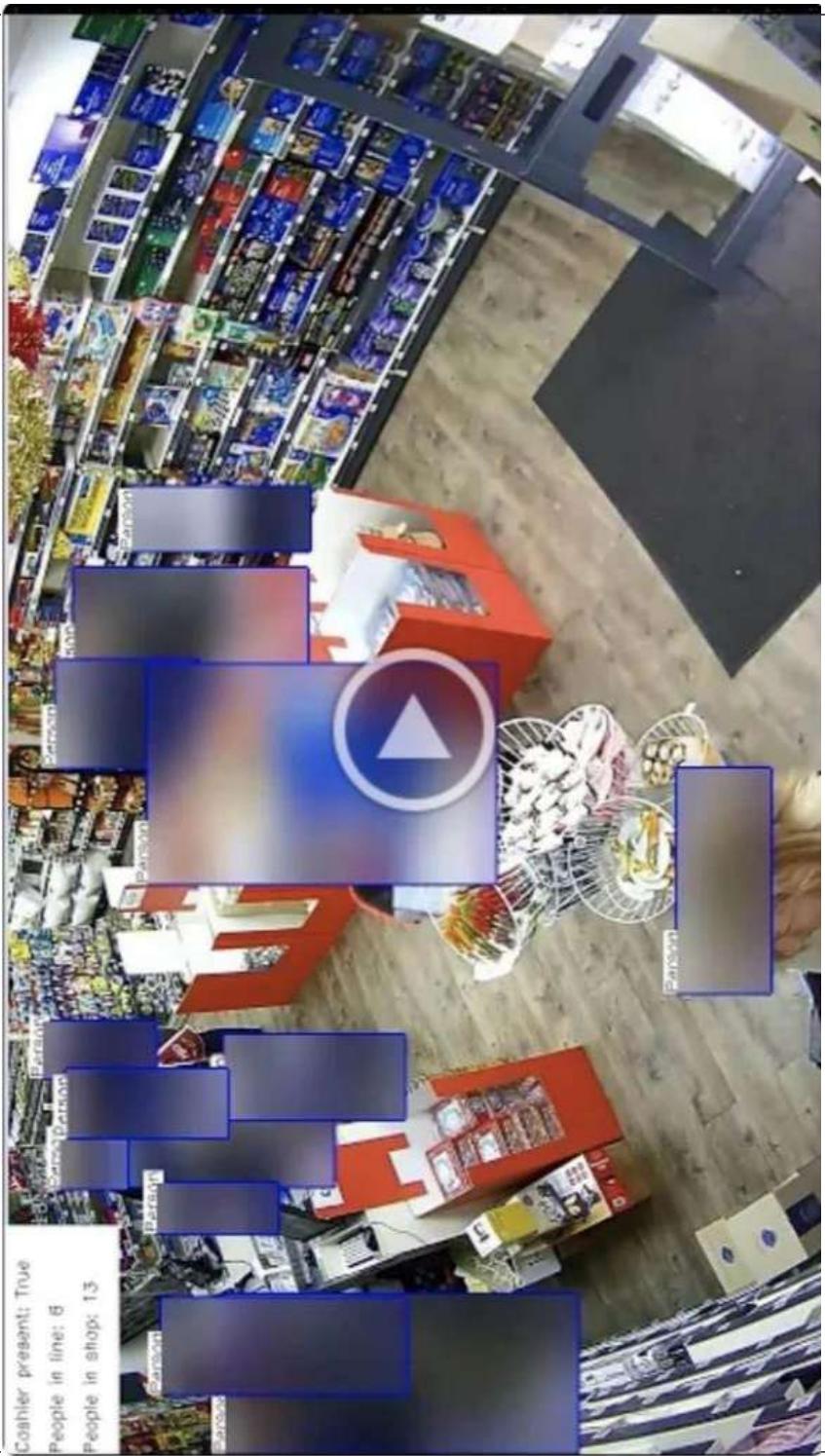
- Industry 4.0

- Industrial machinery control and monitoring
- Data-driven production line optimization

- IoT analytics for real estate

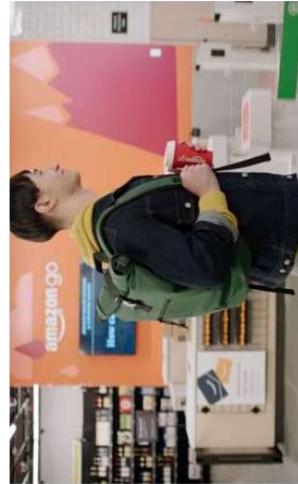
- Controlling smart devices
- Increasing effectiveness of smart buildings

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How to enjoy Just Walk Out shopping



3. Walk out



2. Shop



1. Enter at gate

<https://www.amazon.com/b?ie=UTF8&node=16008589011>

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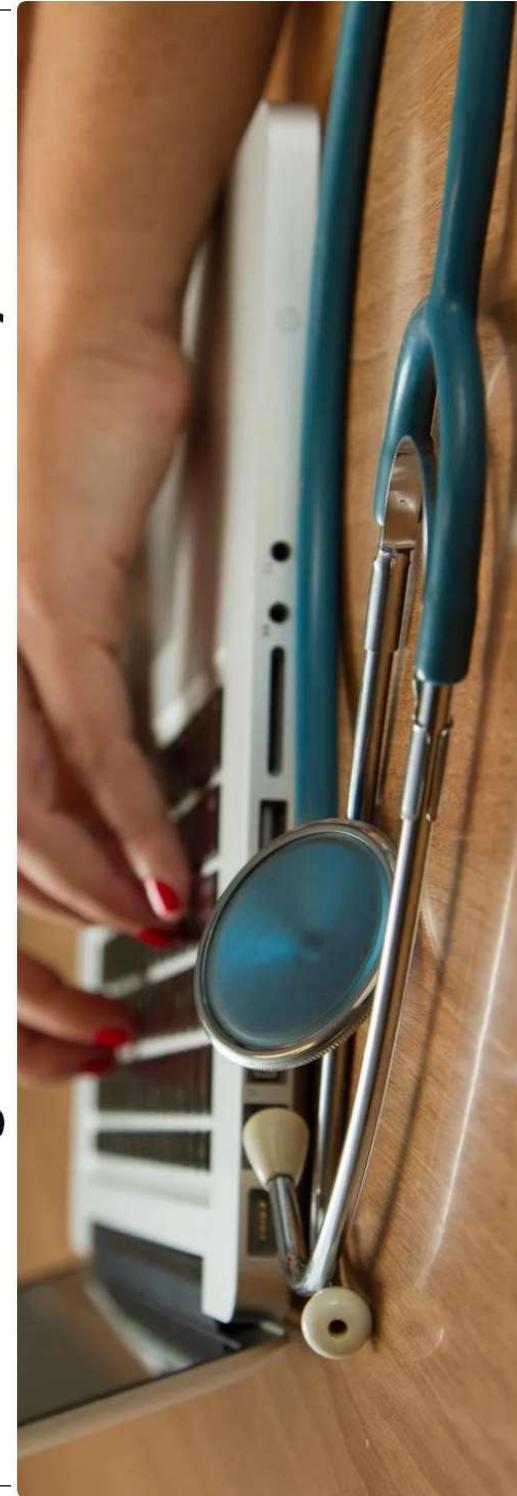


What is smart agriculture? The definition and market size



<https://easternpeak.com/blog/iot-in-agriculture-technology-use-cases-for-smart-farming-and-challenges-to-consider/>

What Is Telemedicine, and How Has It Changed the Healthcare Industry?



<https://www.netguru.com/blog/what-is-telemedicine>